

Renesas RA Family

Getting Started with GUIX Thermostat Application

Introduction

This application, which is a Thermostat application, provides a reference for developing complex multi-threaded applications with a touch screen graphical Human Machine Interface (HMI) by using Renesas FSP and Azure RTOS GUIX. It describes steps to create a basic GUIX for FSP, integrates touch driver, handles multiple hardware accesses, system updates, and event handling.

This application is developed using the Renesas RA Flexible Software Package (FSP), which provides a quick and versatile way to build secure connected Internet of Things (IoT) devices using the Renesas RA family of Arm microcontrollers (MCUs). RA FSP provides production ready peripheral drivers to take advantage of the RA FSP ecosystem along with Azure RTOS GUIX library and Azure RTOS. "In addition, FSP also provides Ethernet, USB, File System and other middleware stacks as well. This powerful suite of tools provides a comprehensive, integrated framework for rapid development of complex embedded applications.

This application note assumes that you are familiar with the concepts associated with writing multi-threaded applications under a Real Time Operating System (RTOS) environment, such as Azure RTOS. This application note makes use of RTOS features such as threads and semaphores. Prior experience in using Azure RTOS would be helpful for easy understanding of the provided application project. For more detailed information on Azure RTOS features, refer to the Azure RTOS User Manual.

The Graphics application is developed using the Renesas e² studio Integrated Solution Development Environment (IDE). e² studio is integrate with the FSP platform installer, which can be downloaded from Renesas website. The intuitive configurators and code generators in e² studio and FSP will help the application developers in creating such complex multi-threaded graphics applications very quickly. This application note walks you through all the necessary steps in creating, building and running a complex graphics project, including the following:

- Board setup
- Install tools
- Build and run application
- Azure RTOS GUIX Studio project integration
- Setup Azure RTOS GUIX Studio project
- Add Touch Driver
- Create FSP GUIX project
- Hardware Setup
- Using the General Purpose Timer to drive a PWM backlight control signal

Required Resources

Development tools and software

- e² studio IDE 2023-04 or greater
- Renesas Flexible Software Package (FSP) v4.4.0 or later
- Azure RTOS GUIX Studio V6.2.1.1 or later

Hardware

- Renesas EK-RA6M3G kit (RA6M3 MCU Group)
(<https://www.renesas.com/us/en/products/software-tools/boards-and-kits/eval-kits/ek-ra6m3g.html>)

Reference Manuals

- RA Flexible Software Package Documentation Release v4.4.0
- Azure RTOS GUIX and GUIX Studio v6.2.1.1

- Renesas RA6M3 Group User's Manual Rev.1.01
- EK-RA6M3G-v1.0 Schematics

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1. Installing Tools

1.1 Overview

In this section you will copy the application note (AN) materials to your PC and install e² studio v2023-04/FSP v4.4.0 and Azure RTOS GUIX Studio v6.2.1.1.

1.2 Procedural Steps

1. If you already have e² studio v2023-04 with FSP v4.4.0 or later installed, you can skip this step. Otherwise, you can download it from this [link](#).
2. You can get Azure RTOS GUIX Studio v6.2.1.1 or greater from this [link](#). If it goes well, you will see the window in the next step on the web browser.
Note: It needs Microsoft Store working on your PC to install Azure RTOS GUIX Studio.
3. Click **Get** to start installing Azure RTOS GUIX Studio.

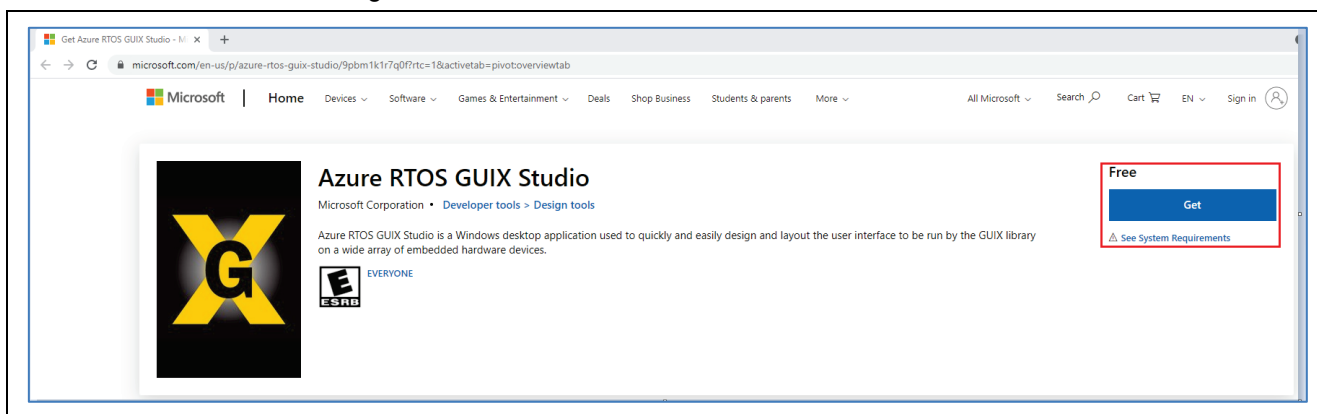


Figure 1. Clicking Get to Start Installing Azure RTOS GUIX

4. Click **Open Microsoft Store** to continue installing Azure RTOS GUIX Studio.

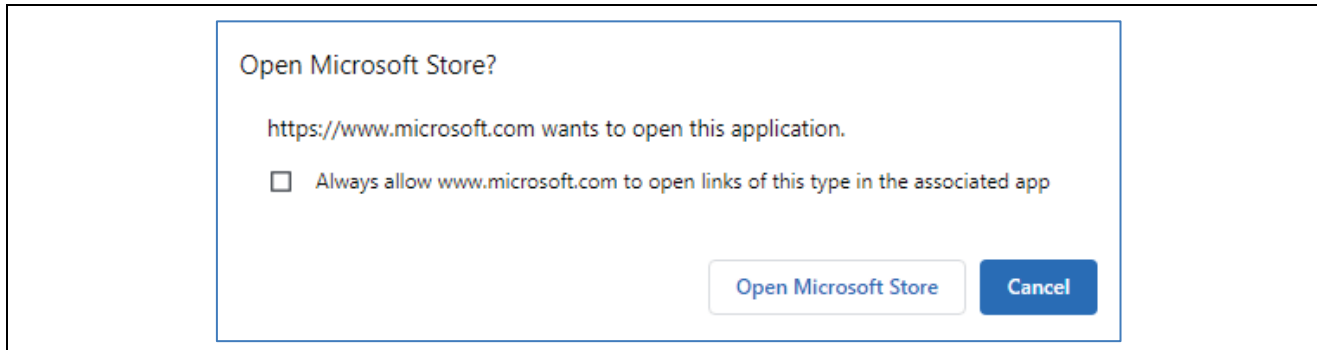


Figure 2. Clicking Open Microsoft Store

5. Click **Install** to continue. A window shows up to ask for a Microsoft account, which is seen in the next step.

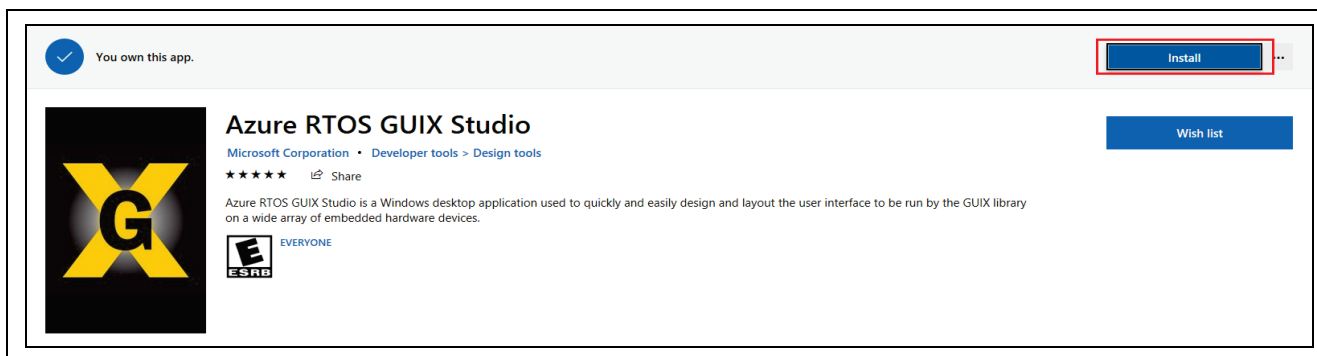


Figure 3. Installing Azure RTOS GUIX

6. Ignore it by clicking “X” on the top-right to close this pop-up window and continue Azure RTOS GUIX Studio installation.

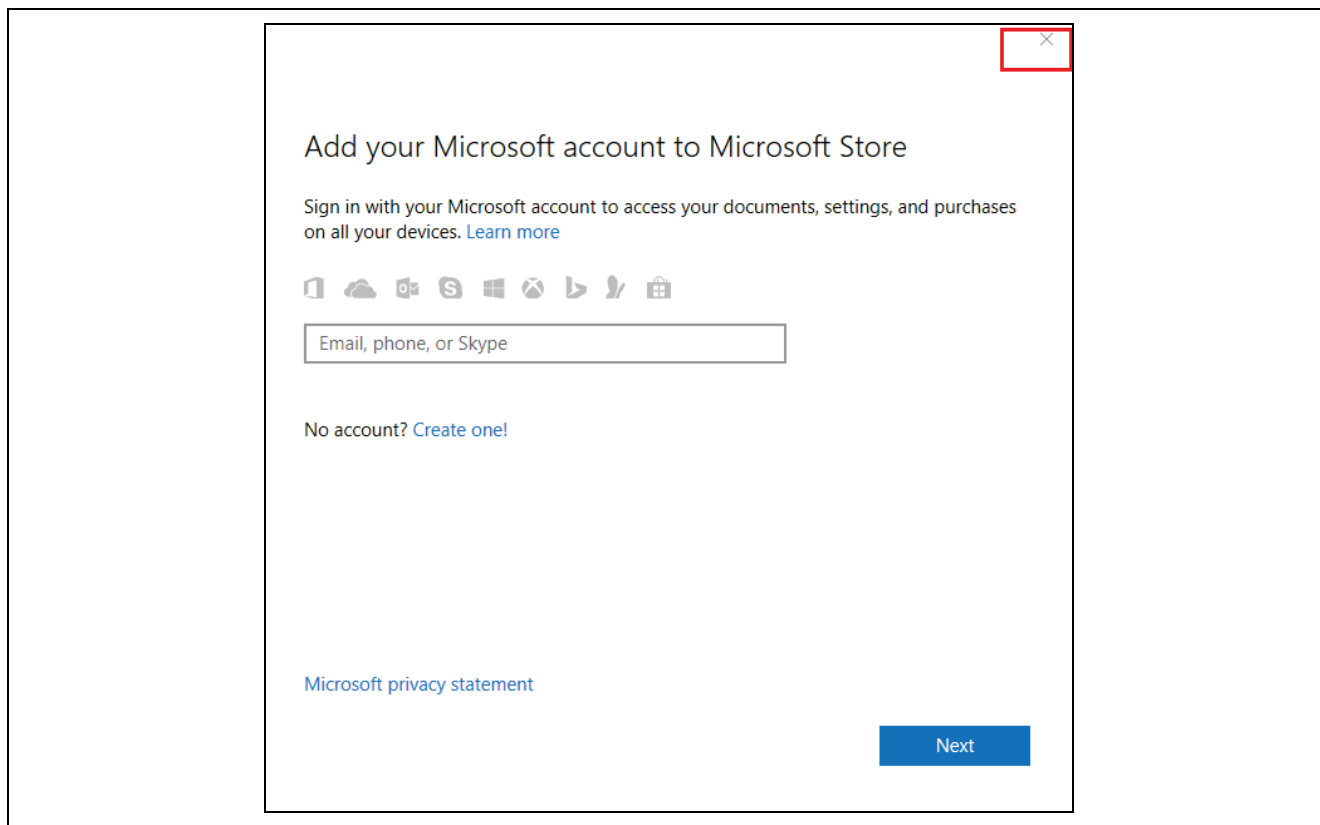


Figure 4. Closing Pop-up Window to Continue Installing Azure RTOS GUIX

7. Downloading and installation of Azure RTOS GUIX Studio starts.

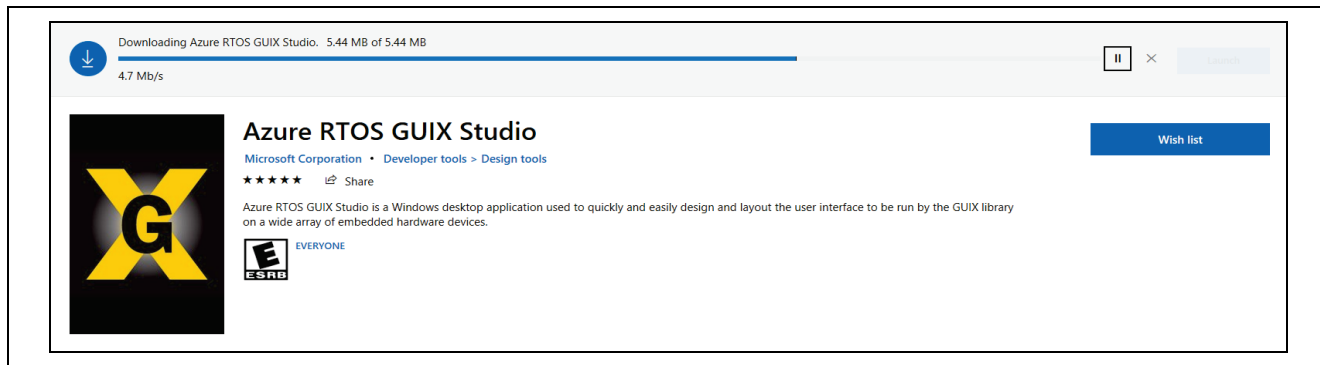


Figure 5. Starting of Downloading and Installation

8. Click **Launch** to launch Azure RTOS GUIX Studio.

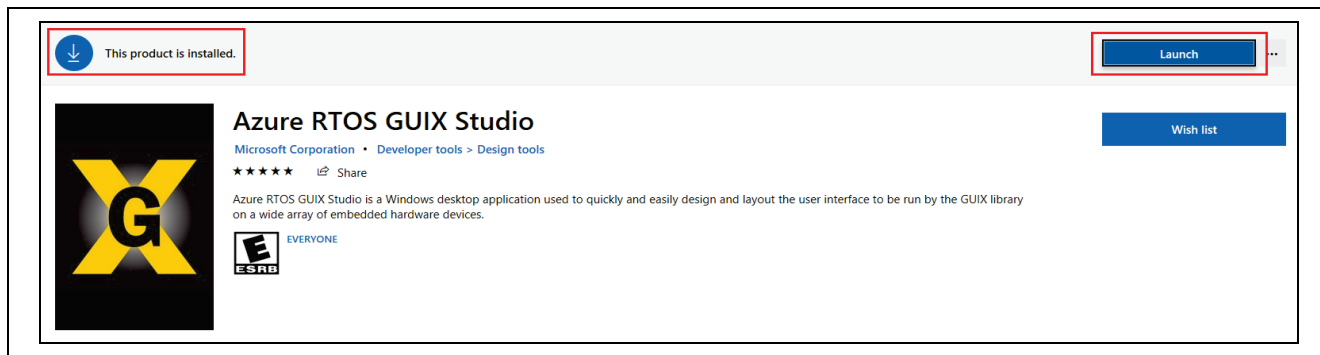


Figure 6. Launching to Start Azure RTOS GUIX Studio

9. Azure RTOS GUIX Studio launched.

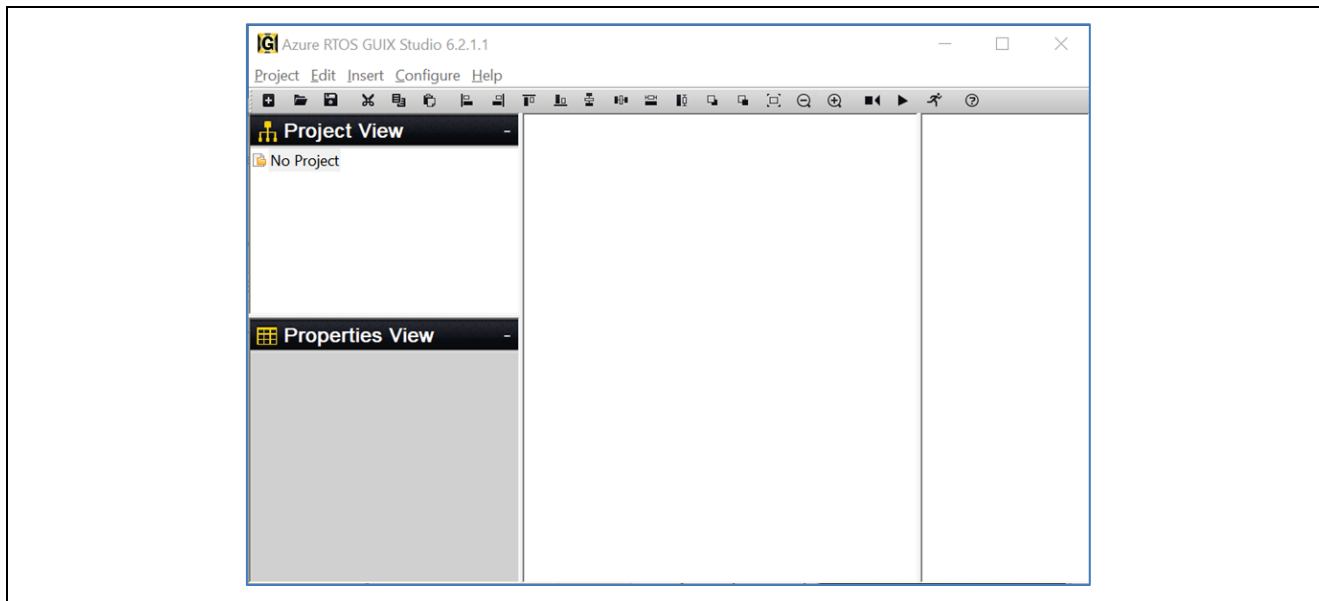


Figure 7. Azure RTOS GUIX Studio Launched

10. Close Azure RTOS GUIX Studio, for now, you will open it again later.

2. Create Application Note Project

2.1 Overview

In this section, you will create a project to which you will add pre-written source code and integrate it with a pre-created Azure RTOS GUIX Studio project.

2.2 Procedural Steps

1. Create a new **RA C/C++ project**. Name it as `Thermostat_GUIX_EK_RA6M3G`.

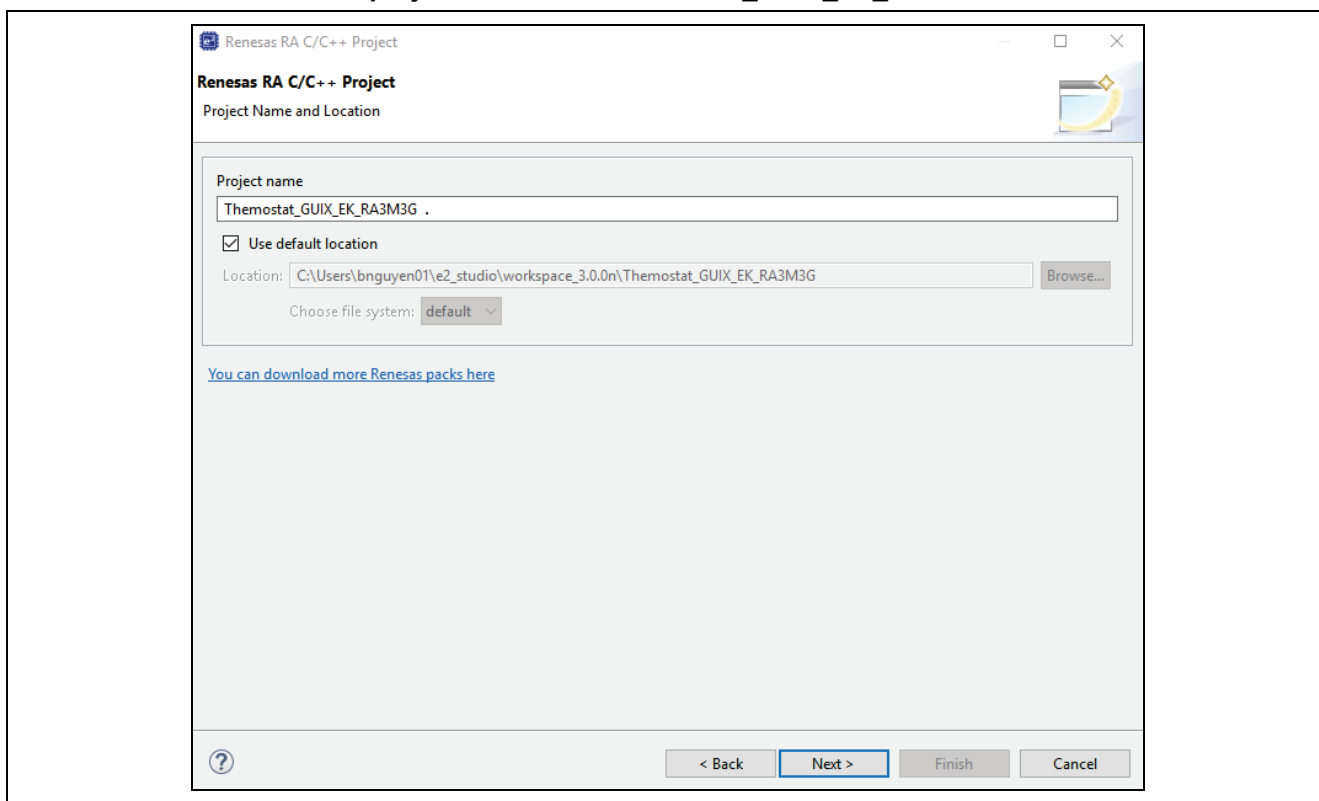


Figure 8. Creating New RA C/C++ Project

2. Set board to EK-RA6M3G.

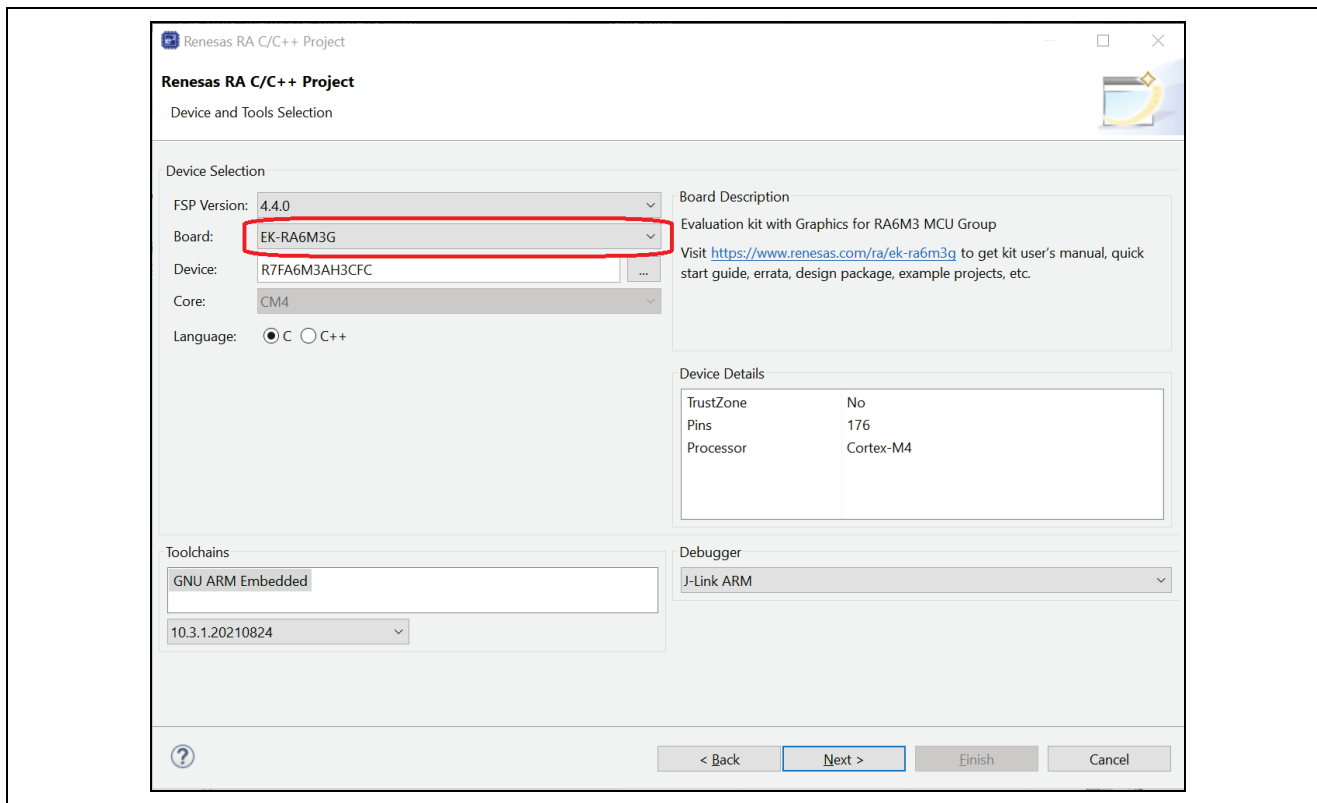


Figure 9. Setting Board to EK-RA6M3G

3. Select Azure RTOS ThreadX (v6.2.1+FSP.4.4.0).

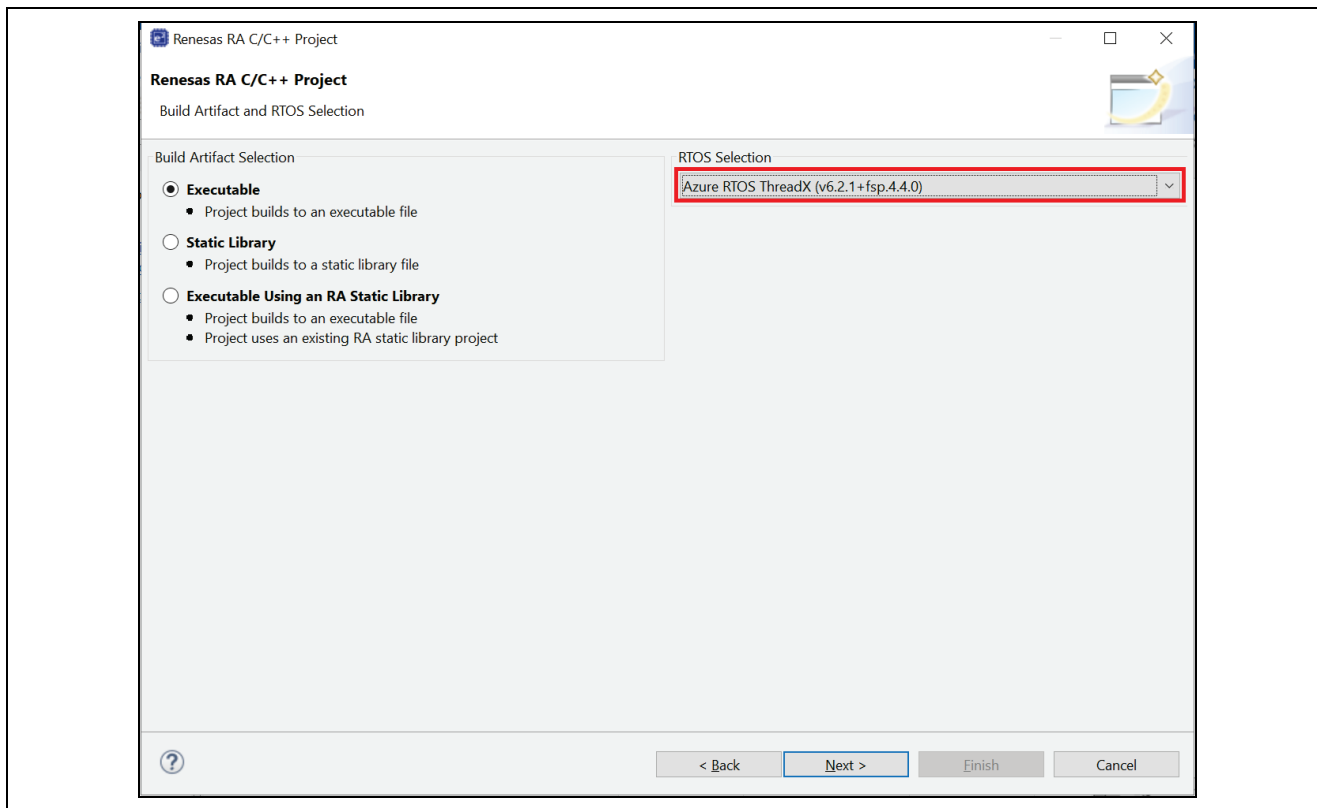


Figure 10. Selecting Azure RTOS ThreadX

4. Use Azure RTOS ThreadX-Minimal template.

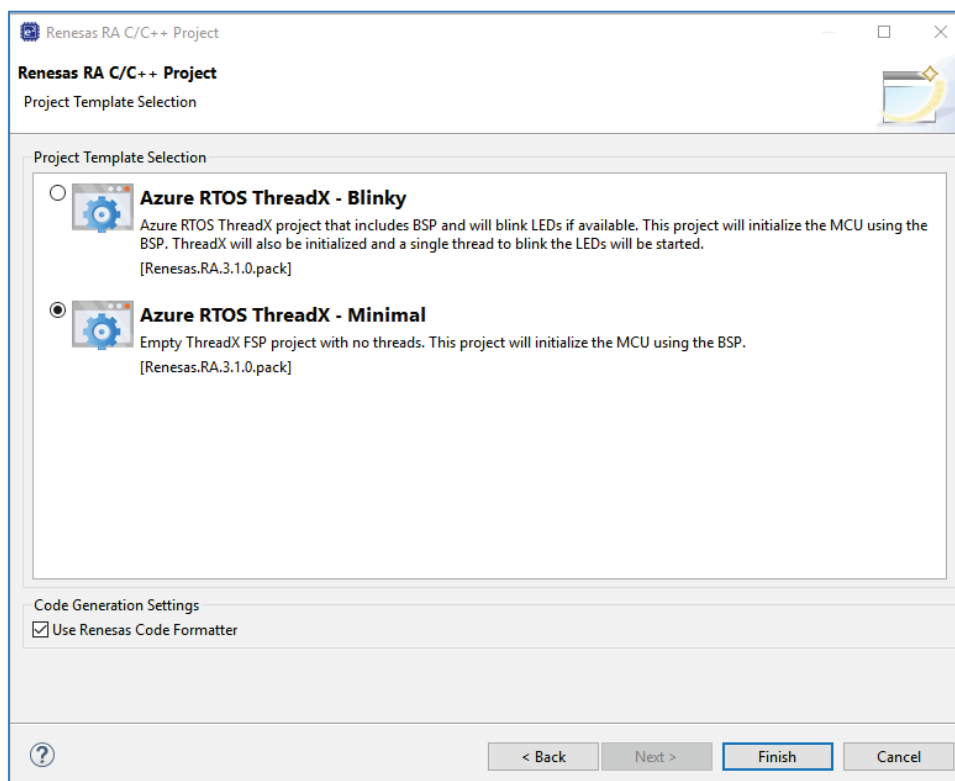


Figure 11. Selecting Azure RTOS ThreadX – Minimal Template

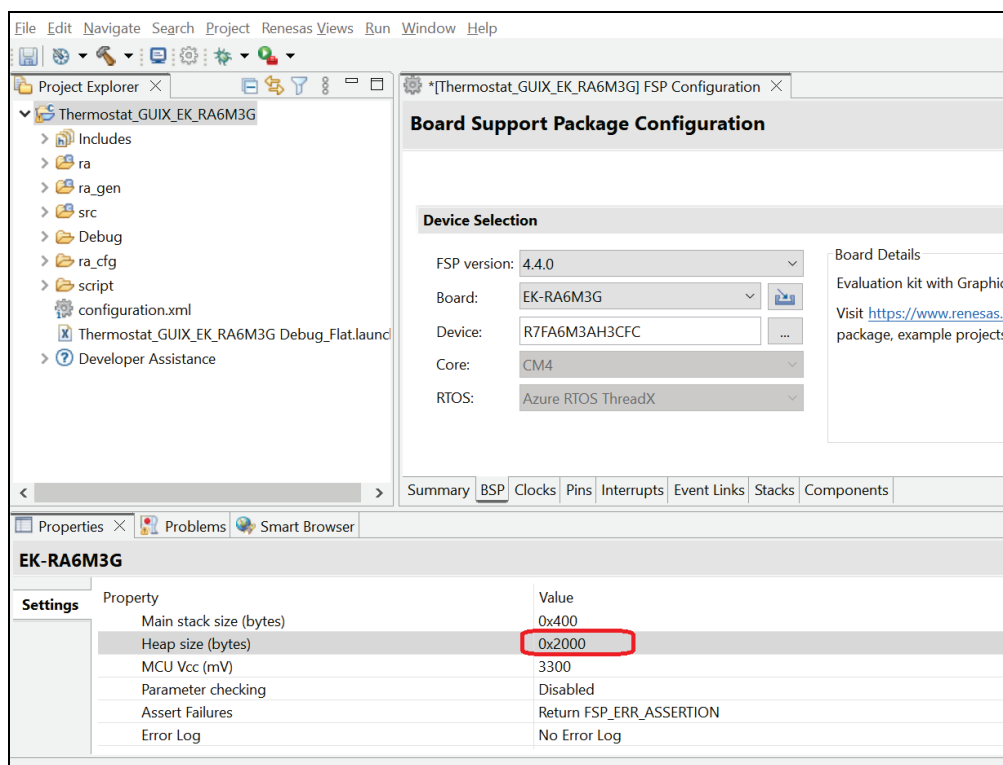
5. Open project configuration, go to **BSP** tab, change Heap size to 0x2000.

Figure 12. Changing Heap size (bytes) in Project Configuration

6. Add a **New Thread** and name it as **System Thread** with the following settings.

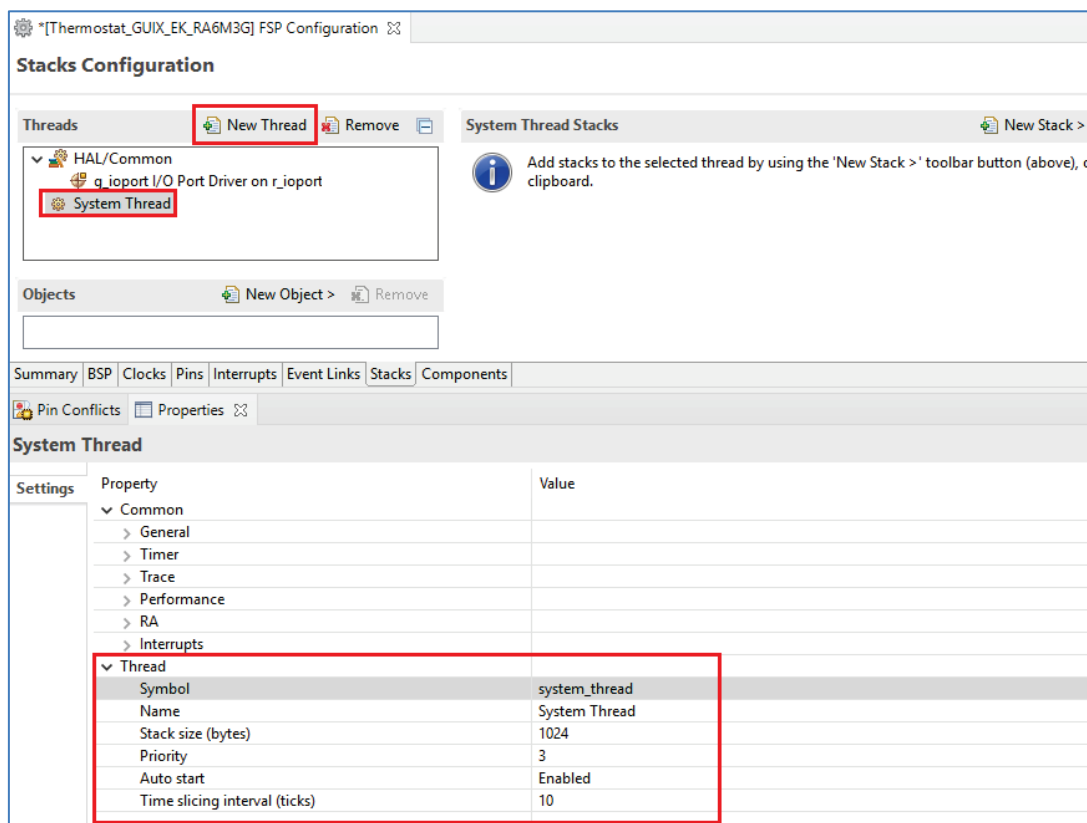


Figure 13. Adding a New Thread and Naming it System Thread

7. Add **Azure RTOS GUIX** to **System Thread**.

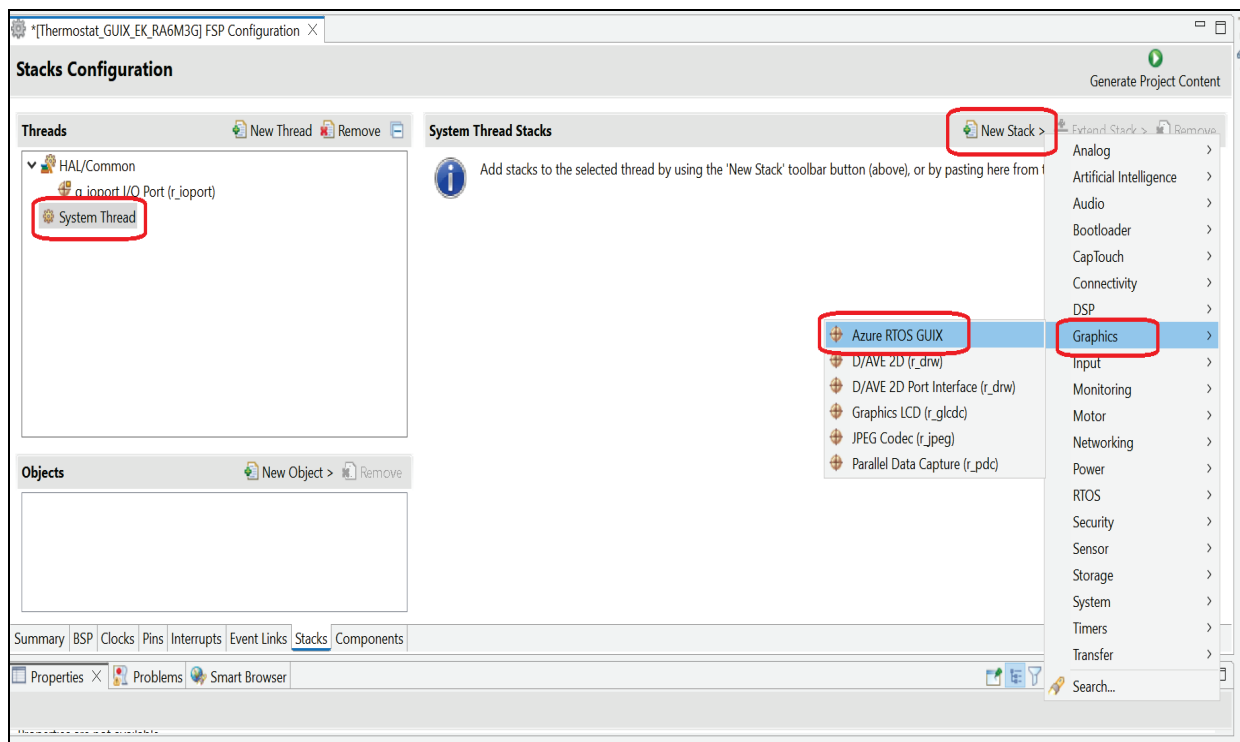


Figure 14. Adding Azure RTOS GUIX to System Thread

8. You do not need to make any changes in GUIX and `r_glcdc` driver configurations. FSP already has them configured properly for EK-RA6M3G.

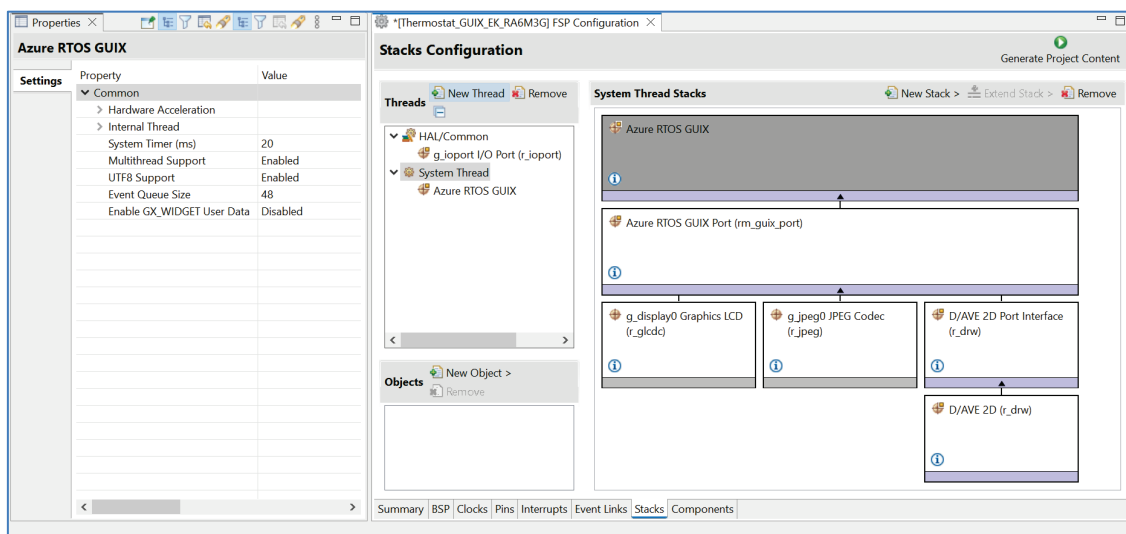


Figure 15. Azure RTOS GUIX Stacks Configuration Window View

9. In **Pin Configuration**, change P603's mode to **Output mode (initial high)** to enable LCD panel backlight.

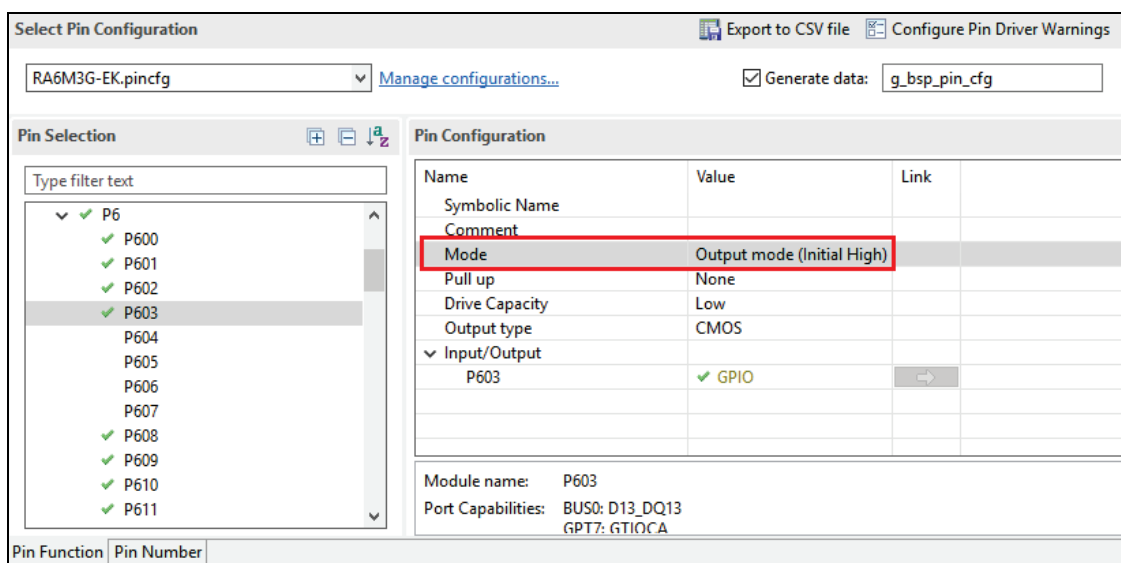



Figure 16. Changing Pin Configuration Mode to Enable LCD Panel Backlight

10. In RA Configurator, click **Generate Project Content** to generate project content. Make sure project is active, click  to build the project. It may take a long period of time to finish building an Azure RTOS/GUIX project on your PC.

11. Copy Azure RTOS GUIX Studio project to e² studio project (Thermostat_GUIX_EK_RA6M3G) by copying “**guix_studio**” folder in the application note (**AN**) folder (FSP_GUIX_Thermostat) and pasting it in the Thermostat_GUIX_EK_RA6M3G project.

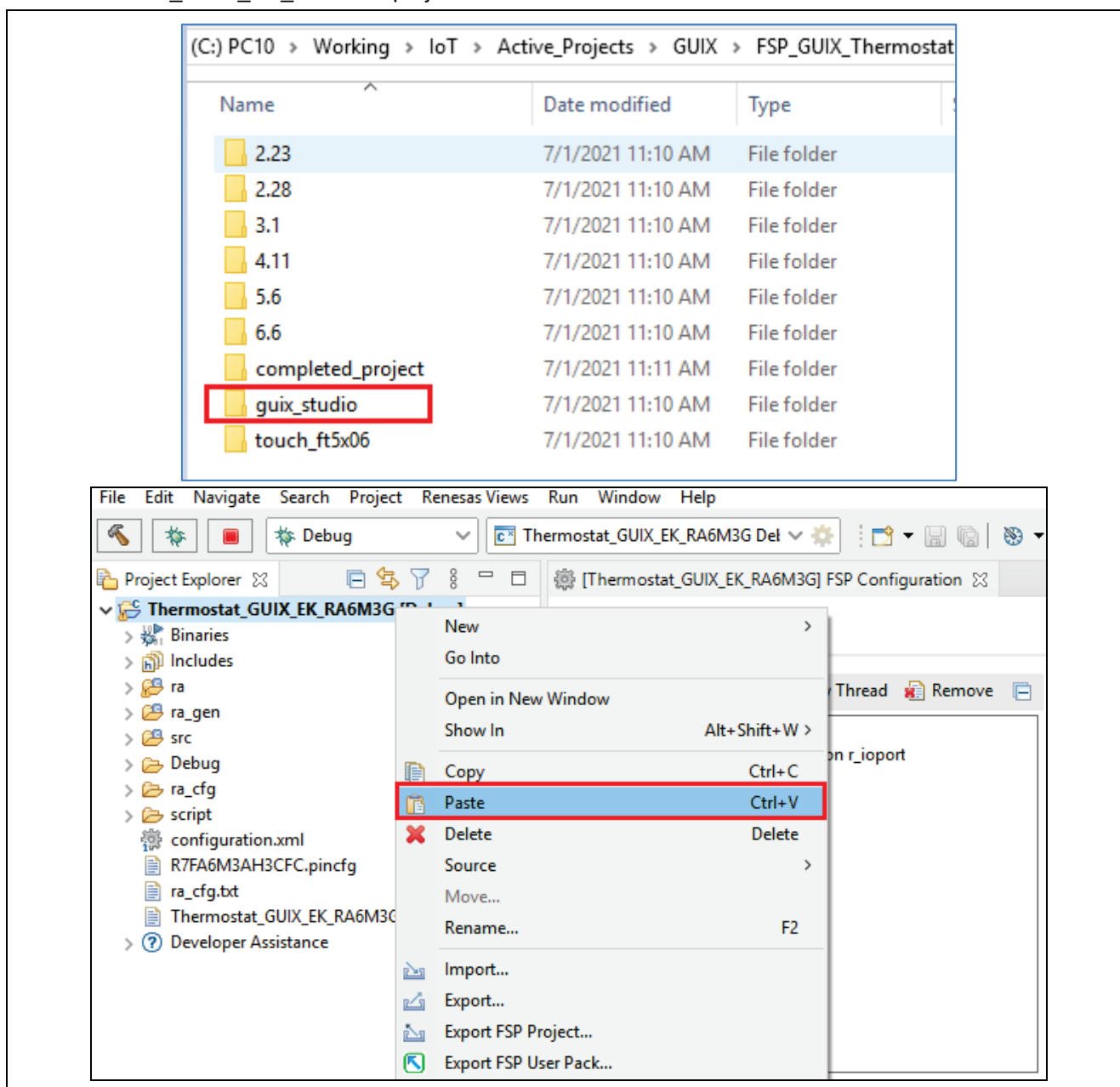


Figure 17. Copying the Azure RTOS GUIX Studio Project to e² studio

12. GUIX Studio project is now in Thermostat_GUIX_EK_RA6M3G project. In e² studio, right-click the “**guix_studio**” folder and exclude it from the build since it contains the Azure GUIX Studio project, which will not be built by FSP.

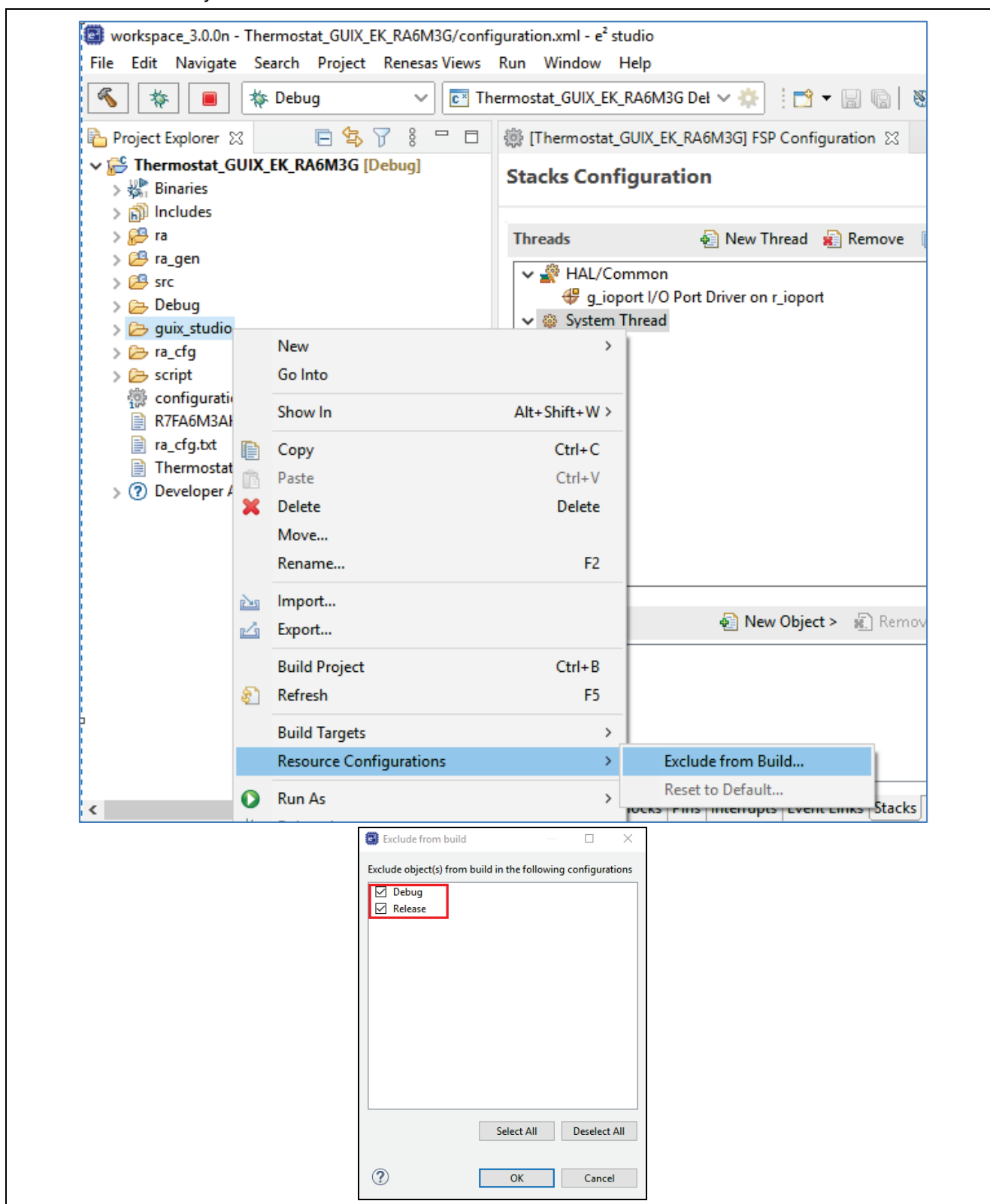


Figure 18. Excluding guix_studio Folder from the Build

13. Get to Thermostat_GUIX_EK_RA6M3G project folder by right click the e² studio project and select “**System Explorer**” as shown below.

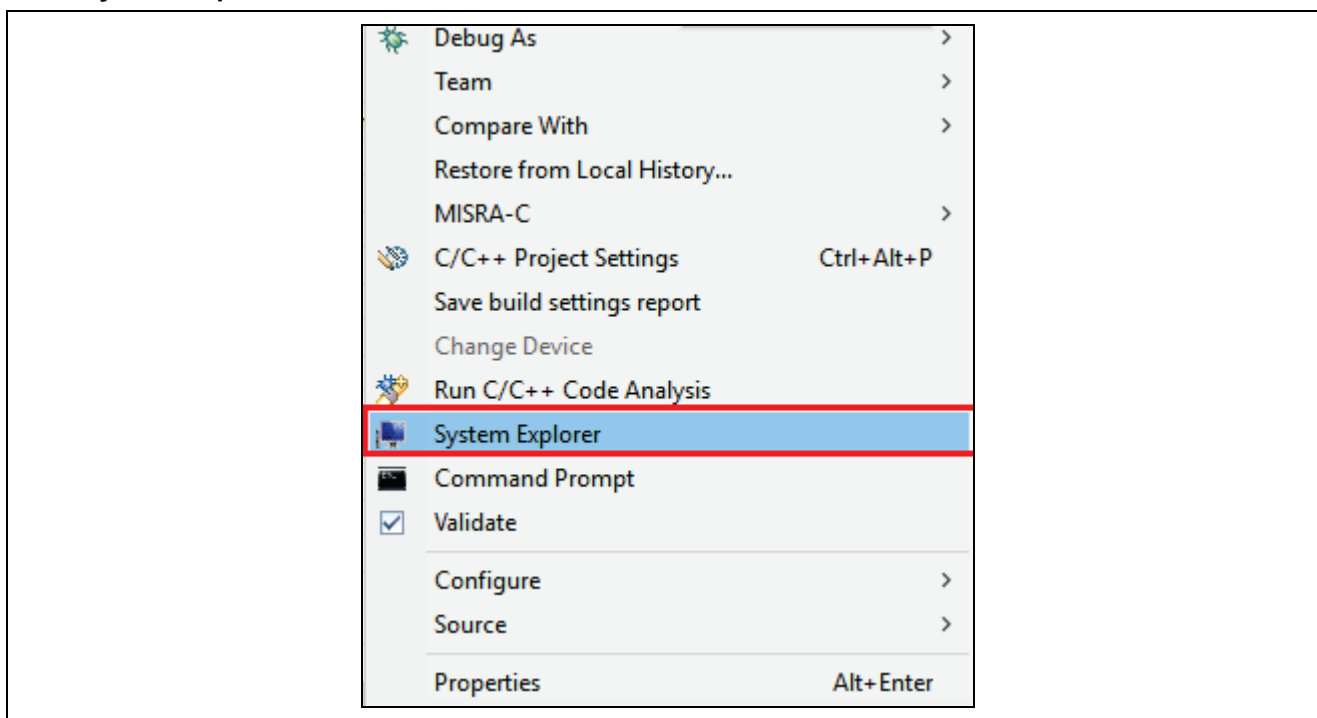


Figure 19. Selecting System Explorer

14. Open **thermostat.gpx** project file in “**guix_studio>GNU**” sub-folder in your Thermostat_GUIX_EK_RA6M3G folder. If you have several GUIX Studio versions in your system, make sure you choose the right one, which is **v6.2.1.1 or later**.

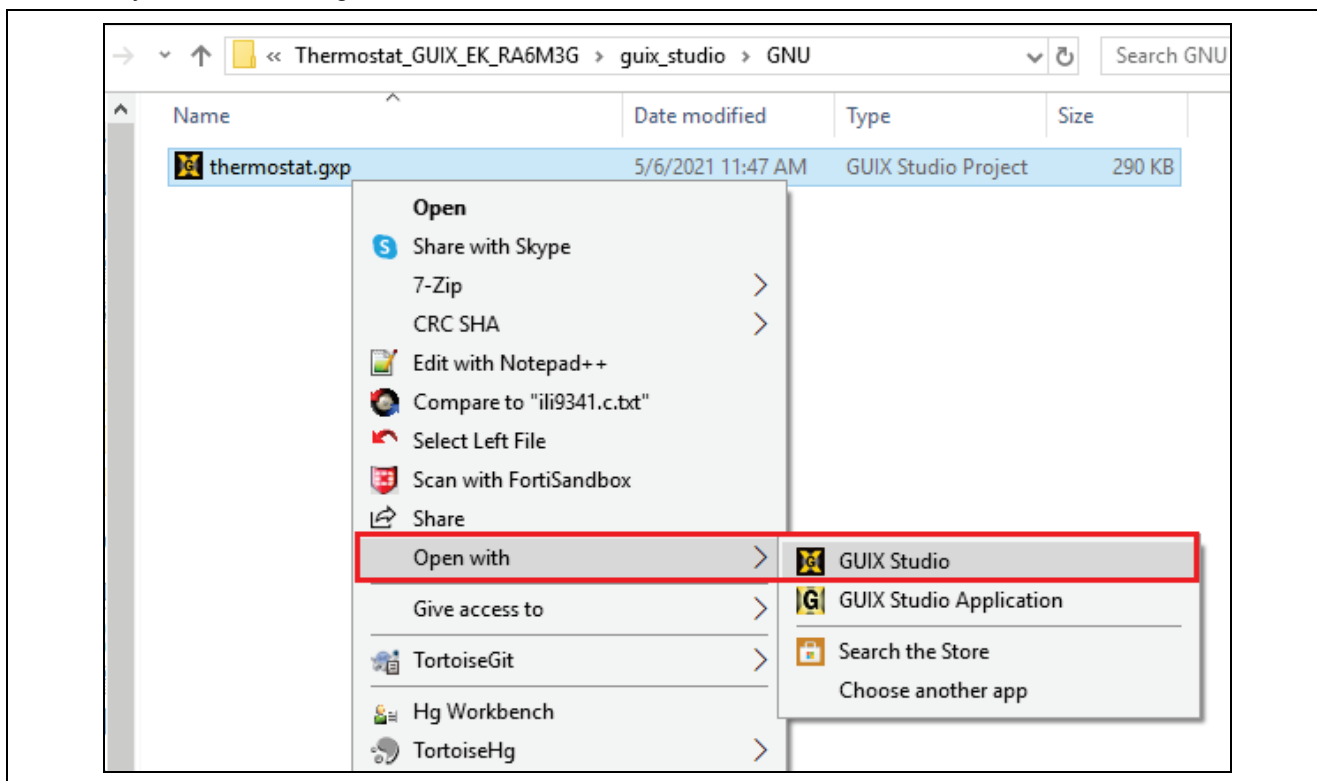


Figure 20. Opening the Project File

15. This GUIX Studio project has a complete design of this Thermostat application. The next several steps describe the process to generate resources, application code and integrate them with an e² studio project.

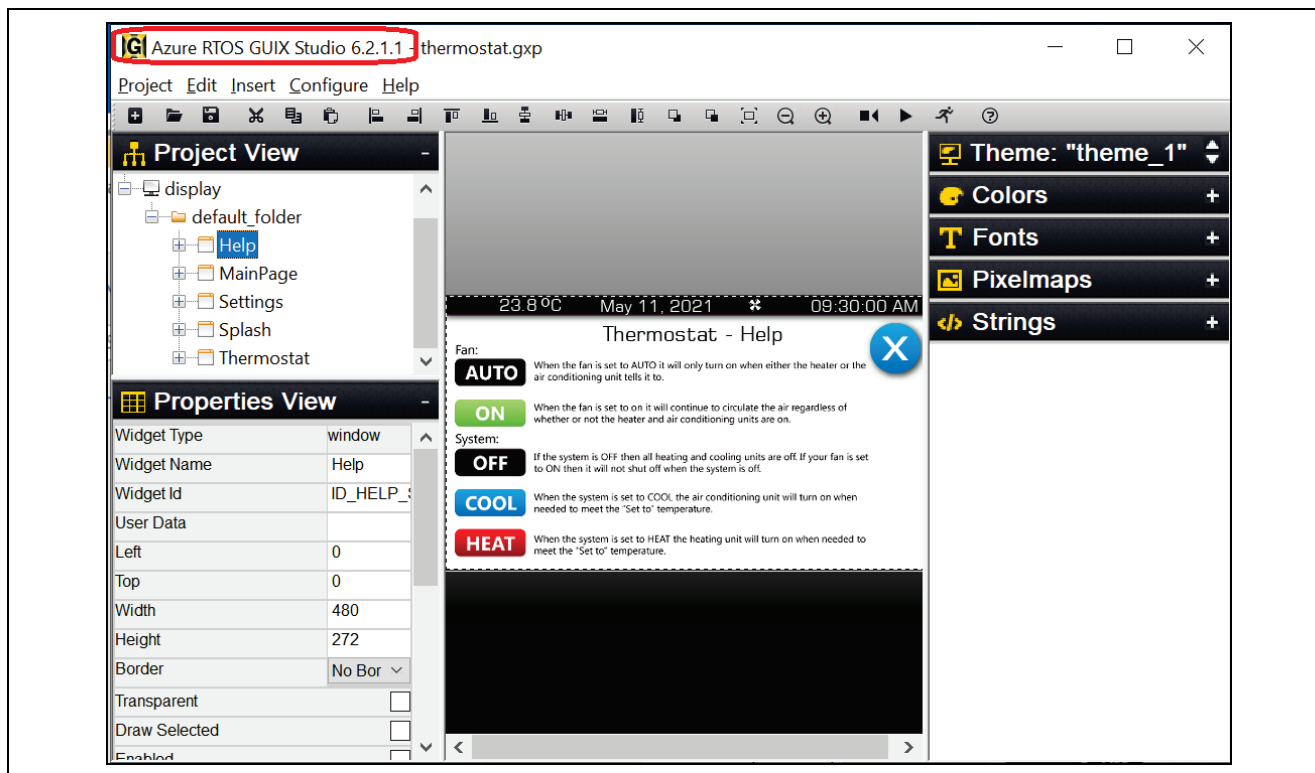


Figure 21. GUIX Studio Thermostat Application View

16. The Azure RTOS GUIX Studio project consists of 5 screens, including Splash, Main Page, Settings, Thermostat and Help from top to bottom:

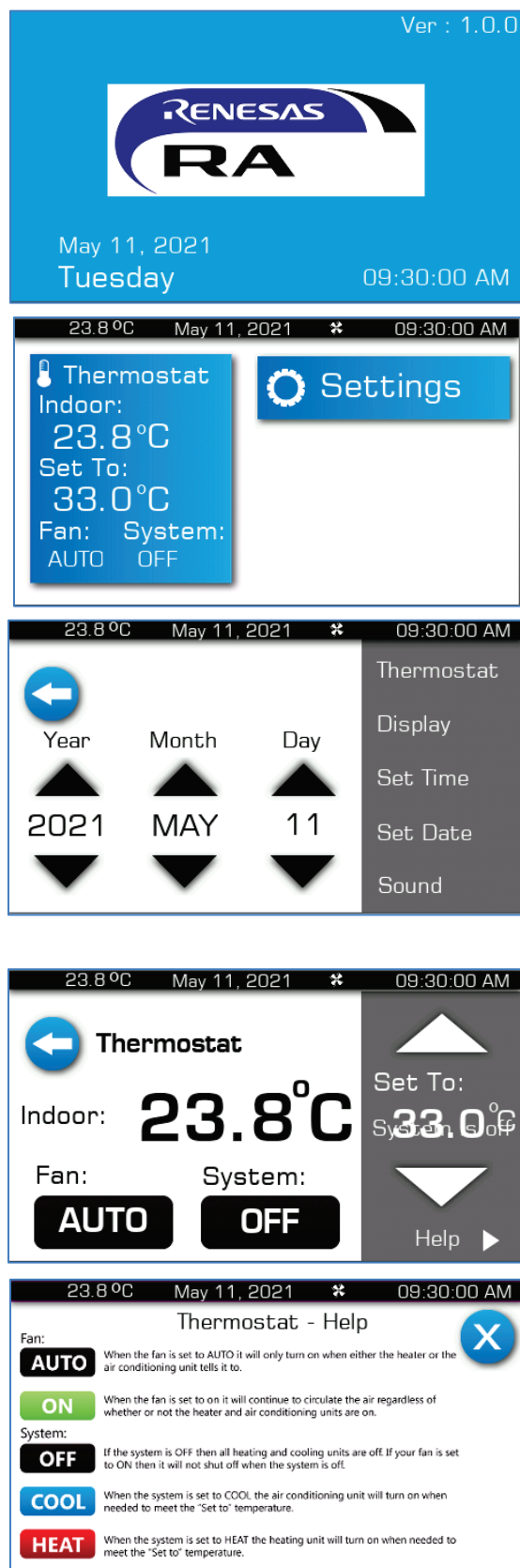


Figure 22. Azure RTOS GUIX Studio Project Screens

17. Click “**Configure->Project/Display**” and confirm the following settings.

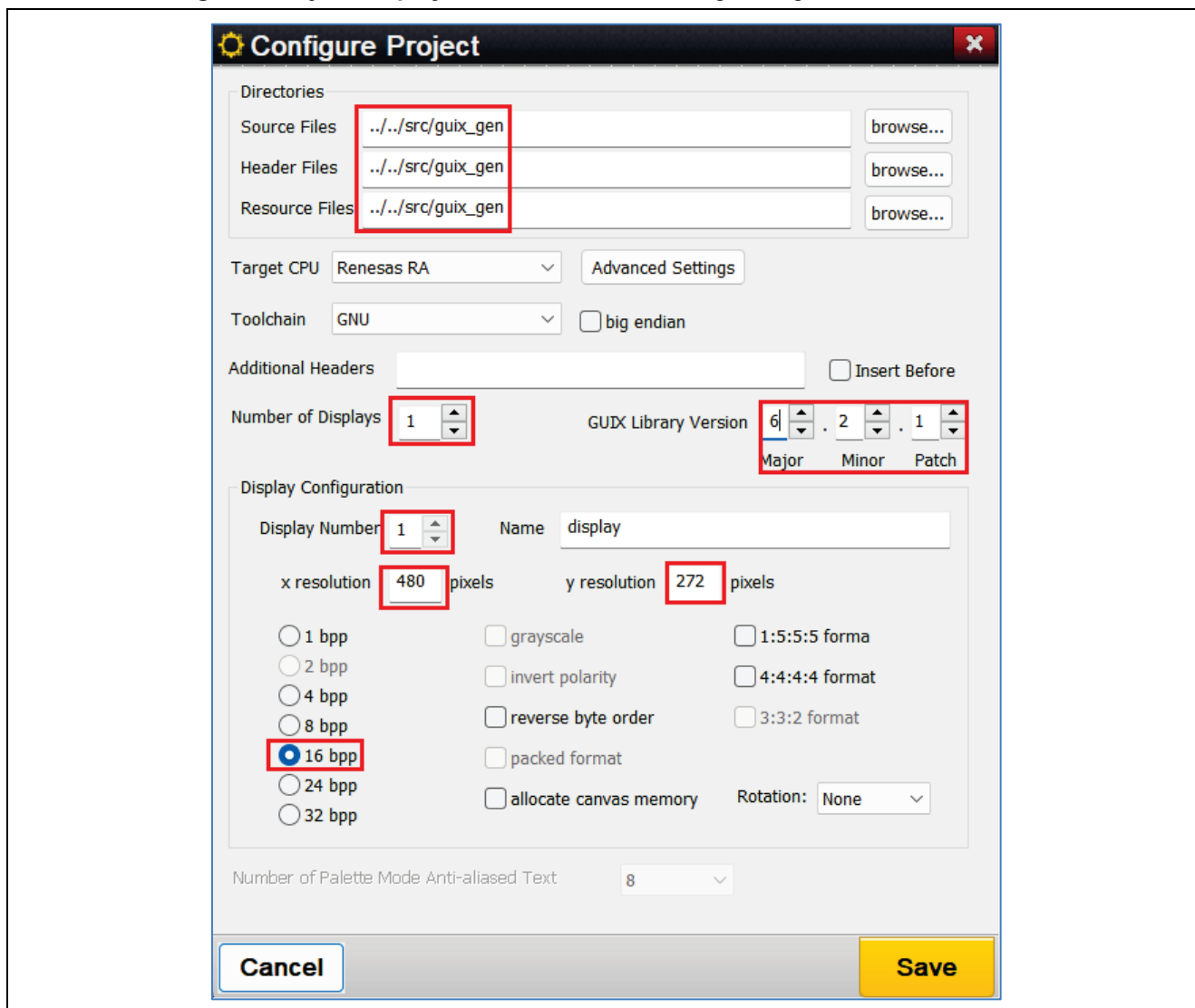


Figure 23. Configure Project Settings

18. Go back e² studio project (Thermostat_GUIX_EK_RA6M3G), right click “src”, then select “New->Folder” and create a folder named “guix_gen”.

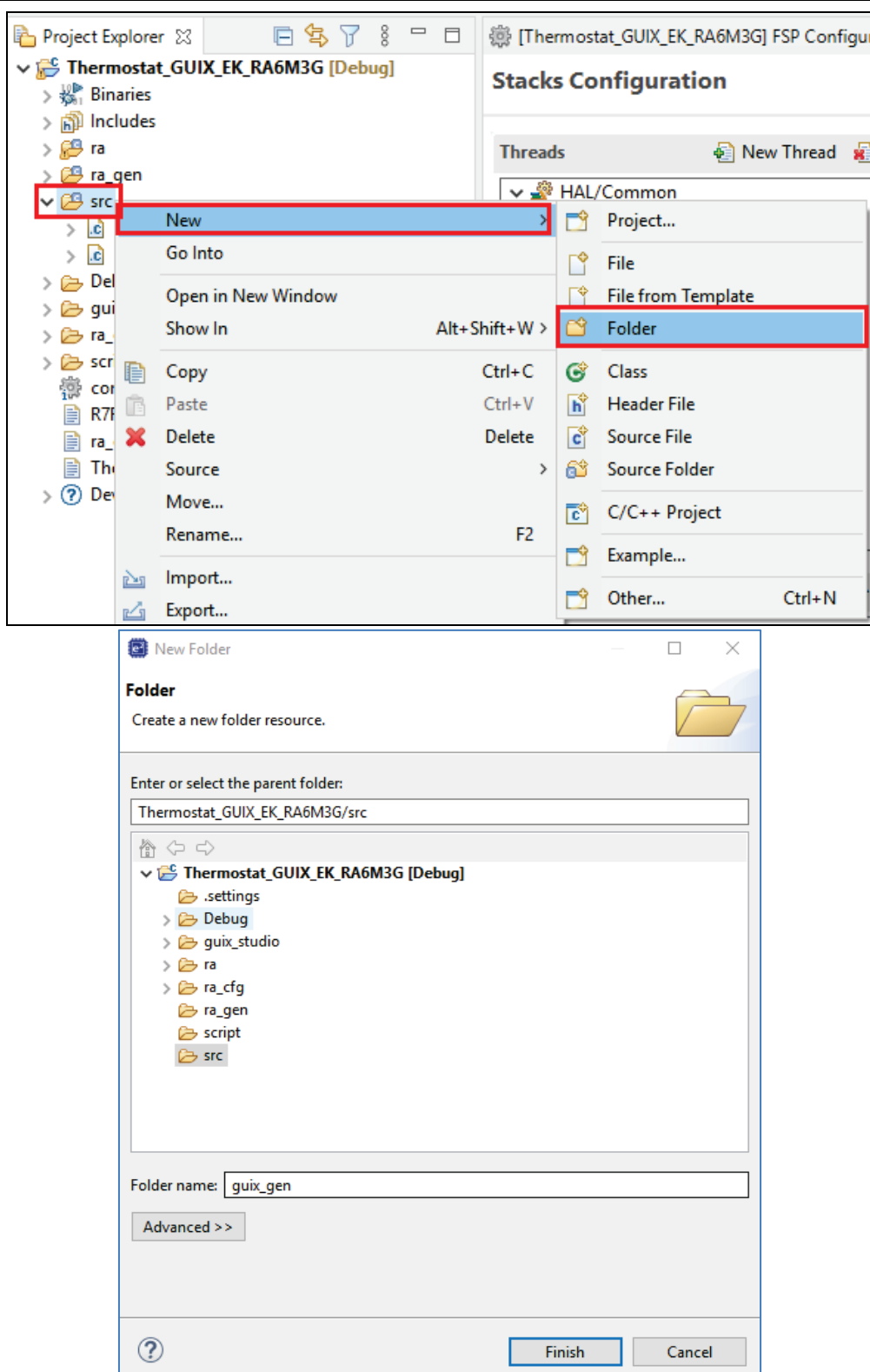


Figure 24. Creating a “guix_gen” in e² studio Project

19. Confirm “guix_gen” is created before moving to next step.

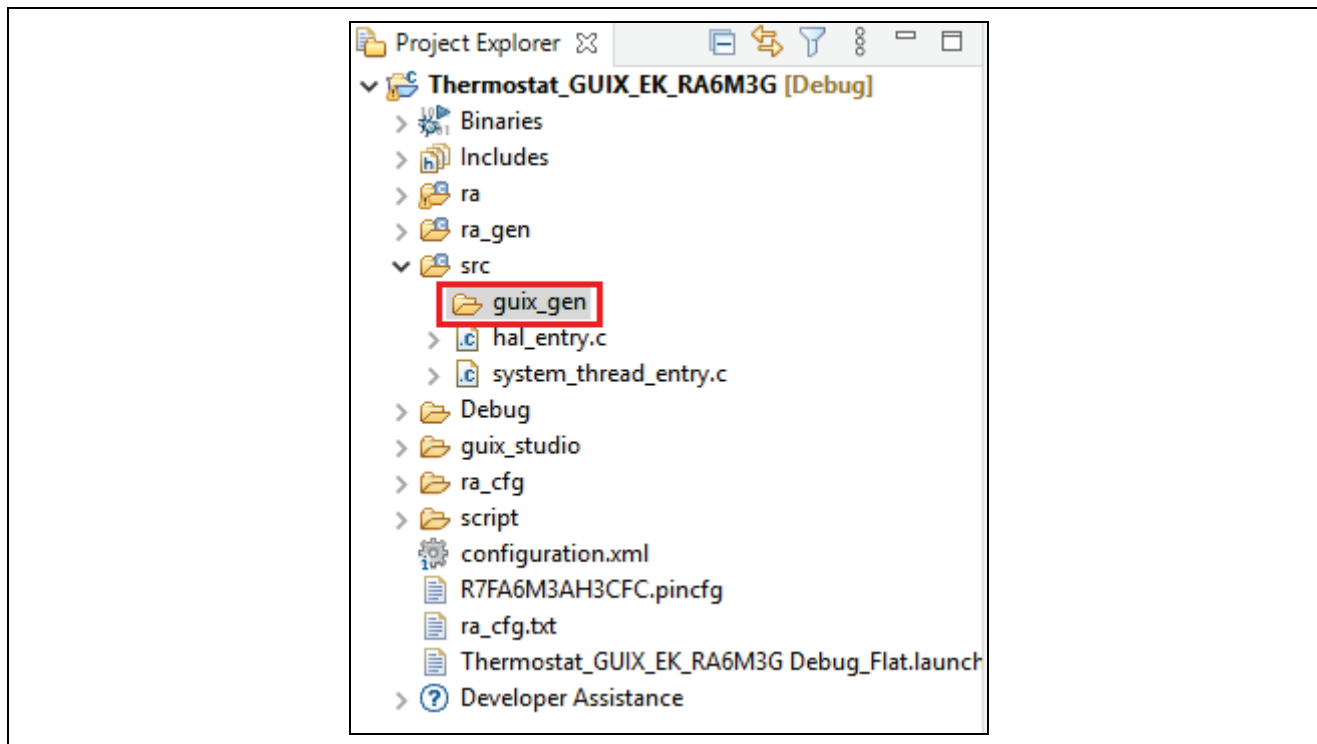


Figure 25. Confirming Creation of “guix_gen”

20. In Azure RTOS GUIX Studio, click **Project->Generate All Output Files** to generate resource files, header files and source files of this GUIX design.

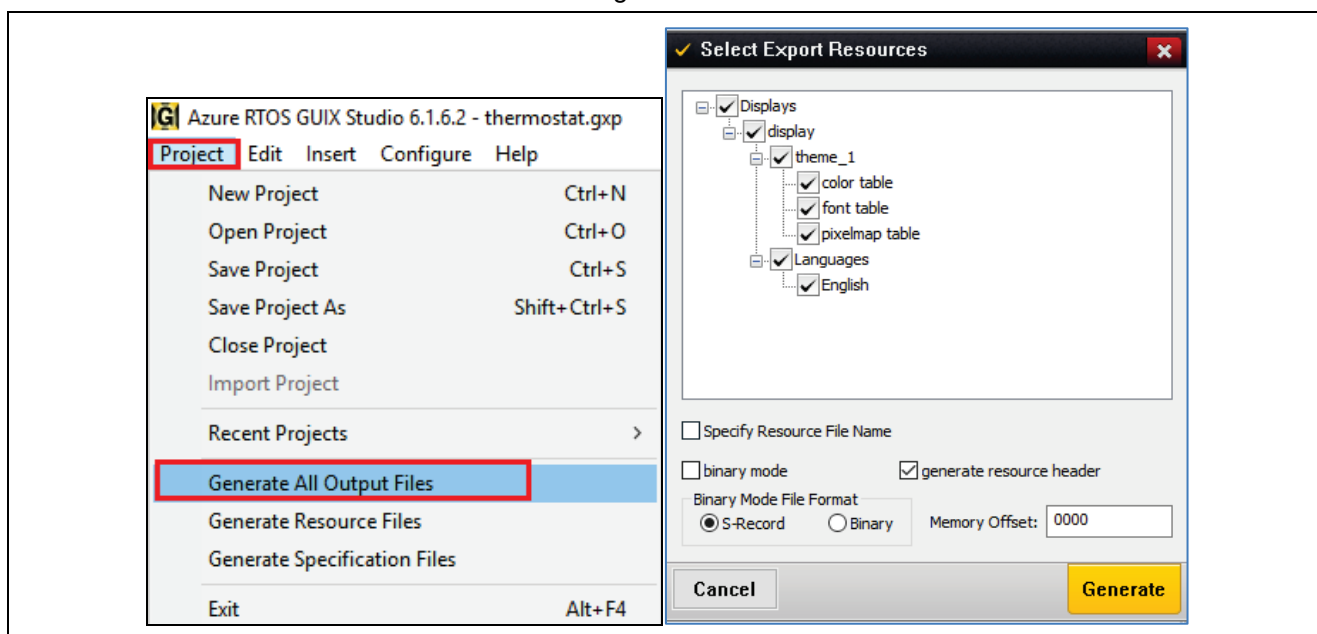


Figure 26. Clicking Generate All Output Files

Click **Generate** to generate all output files. If succeeded, you will see below notification.

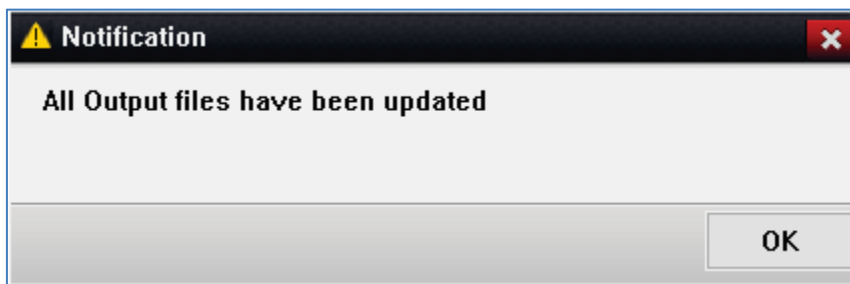


Figure 27. All Output Files Updated Notification

21. All output files are now in “**guix_gen**” folder.

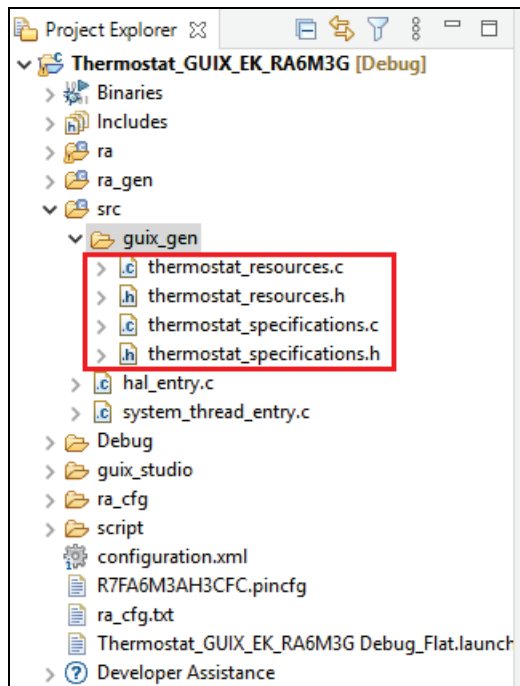


Figure 28. Location of Output Files

22. In the **Azure RTOS GUIX Studio Project**, click “**Splash**” and pick up “**Widget Name**” and “**Event Function**” definitions. These definitions are used to create a screen and handle it in the **e2studio/FSP project**. The other windows have similar definitions.

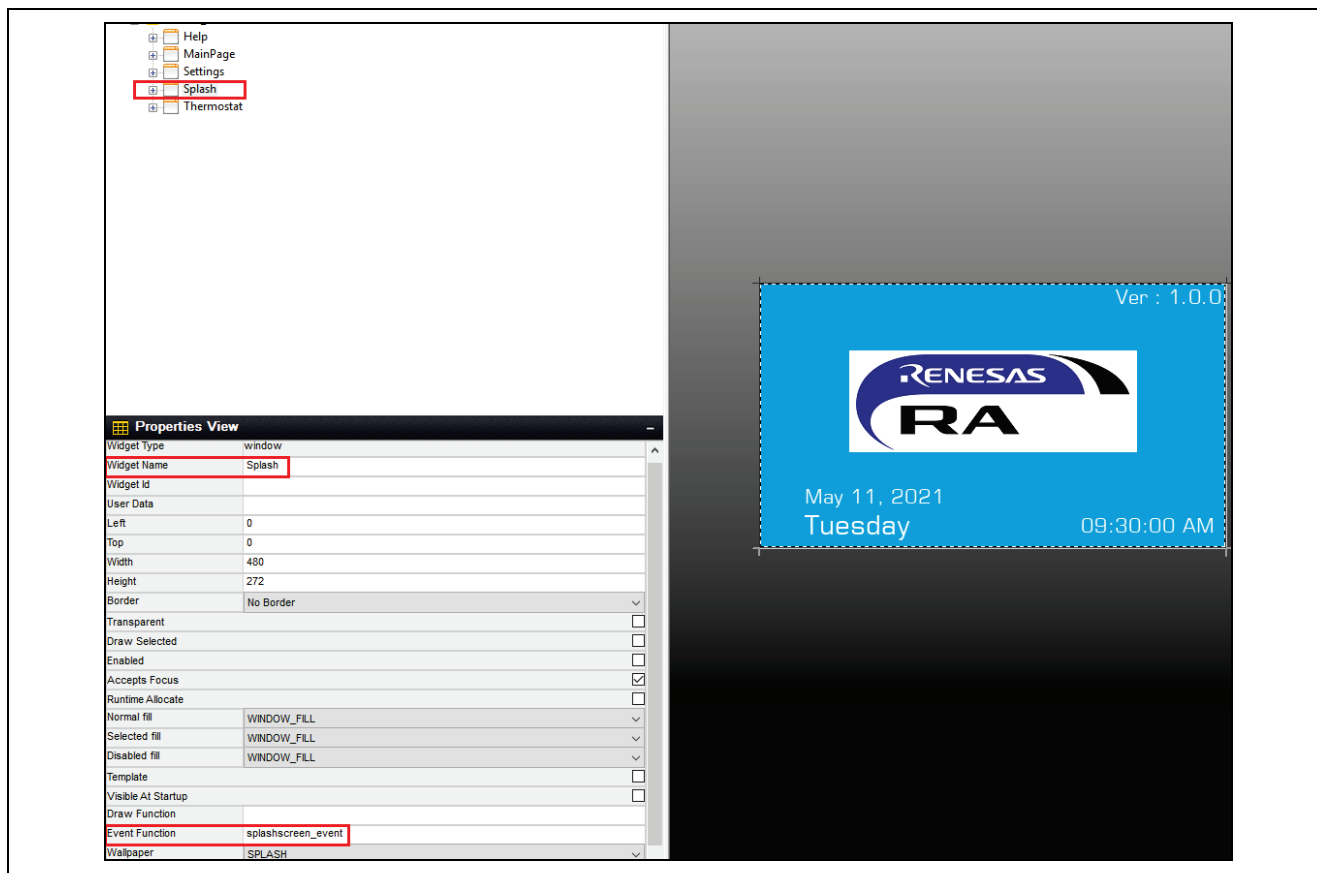


Figure 29. Definitions in the Azure RTOS GUIX Studio Project

23. Copy and replace the files in “**src**” folder in e² studio project with the files in “**2.23**” folder in the AN folder:

- hmi_event_handler.c
- system_thread_entry.c

Build Thermostat_GUIX_EK_RA6M3G project, you will see several warnings but we will address them in later steps.

24. **Code highlight:** The following example creates a screen based on Widget Name in GUIX project and attached it to the root window. In this case, it is the “Splash” screen. Refer to system_thread_entry.c for more details.

```

/* Create a screen and attached it to root window.*/
gx_err = gx_studio_named_widget_create("Splash", (GX_WIDGET *) p_root, (GX_WIDGET **) &p_splash_screen);
if(GX_SUCCESS != gx_err)
{
    APP_ERR_TRAP(FSP_ERR_ASSERTION);
}

```

25. **Code highlight:** An event function associated with a screen needs to be defined to handle events on that screen. Refer to hmi_event_handler.c for more details. All event functions are empty at this point.

```

/*****
 * @brief   Handles all events on the splash screen.
 *
 * @param[in] widget    Pointer to the widget that caused the event
 * @param[in] event_ptr  Pointer to event that needs handling
 *
 * @retval   GX_SUCCESS
 *****/
UINT splashscreen_event(GX_WINDOW *widget, GX_EVENT *event_ptr)
{
    UINT gx_err = GX_SUCCESS;

    return gx_err;
}

```

26. Get your EK-RA6M3G ready to run the project. Connect LCD board to **Graphics Expansion** connector on EK-RA6M3 as shown below.



Figure 30. Connecting LCD Board to Graphics Expansion Connector of EK-RA6M3

27. Connect EK-RA6M3G kit to your PC using **J10**. **Download and Run** Thermostat_GUIX_EK_RA6M3G project, you will see a black screen.

28. Add the following code to **splashscreen_event** function in **hmi_event_handler.c** to show Splash screen. **Build** the e² studio project.

```
switch (event_ptr->gx_event_type)
{
    case GX_EVENT_SHOW:
        gx_err = gx_window_event_process(widget, event_ptr);
        if(GX_SUCCESS != gx_err) {
            while(1);
        }
        break;
    default:
        gx_err = gx_window_event_process(widget, event_ptr);
        if(GX_SUCCESS != gx_err) {
            while(1);
        }
        break;
}
```

Please refer to splashscreen_event function in hmi_event_handler.c in “2.28” folder in the AN folder.

29. **Download and Run** the project, you will see the Splash screen on LCD panel.

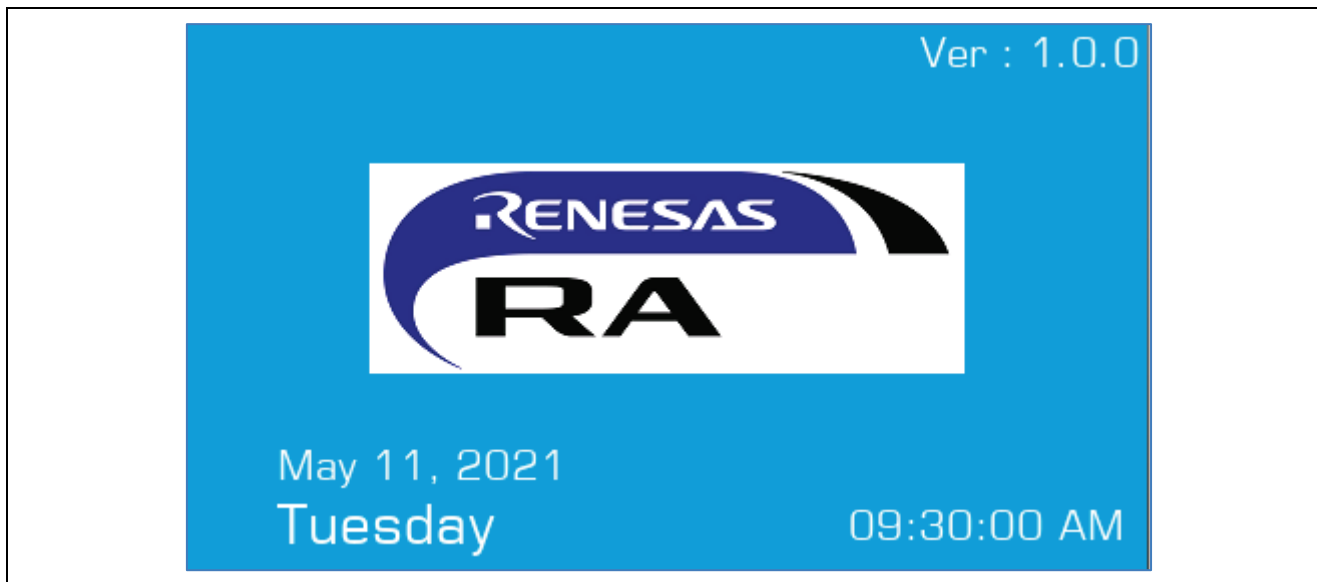


Figure 31. Splash Screen View on LCD

3. Using GUIX Widget Timer to Trigger a Screen Transition

3.1 Overview

In this section, you will implement a simple use of GUIX Widget timer, which is to trigger a screen transition.

3.2 Procedural Steps

1. Copy and replace the files in “src” folder in e² studio project with the files in “3.1” folder in the AN folder:
hmi_event_handler.c
system_thread_entry.c

2. **Code highlight:** The following code in `splashscreen_event` function starts a GUIX Widget timer and trigger a screen transition that hides Splash screen and shows Main Page screen.

```
switch (event_ptr->gx_event_type)
{
    case GX_EVENT_TIMER:
        gx_system_timer_stop(widget, 10);
        toggle_screen(p_mainpage_screen,p_splash_screen);
        break;
    case GX_EVENT_SHOW:
        gx_system_timer_start(widget, 10 , SPLASH_TIMEOUT,
        SPLASH_TIMEOUT);
        gx_err = gx_window_event_process(widget, event_ptr);
        if(GX_SUCCESS != gx_err) {
            while(1);
        }
        break;
    default:
        gx_err = gx_window_event_process(widget, event_ptr);
        if(GX_SUCCESS != gx_err) {
            while(1);
        }
        break;
}
```

3. **Build, Download, and Run** the project, you will see the transition from Splash screen to Main Page screen in about 3 seconds.

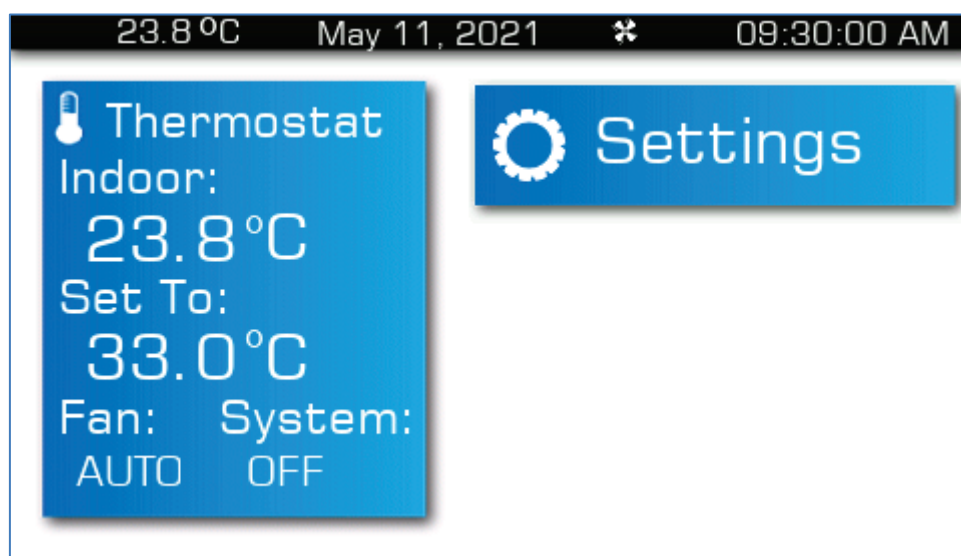


Figure 32. Main Page Screen

4. Add Touch Driver to Thermostat_GUIX_EK_RA6M3G Project

4.1 Overview

In this section, you will add the ft5x06 touch driver to the project to handle touch events on LCD panel.

4.2 Procedural Steps

1. In Thermostat_GUIX_EK_RA6M3G project, create a folder by right-clicking “src”, then select “New->Folder”.

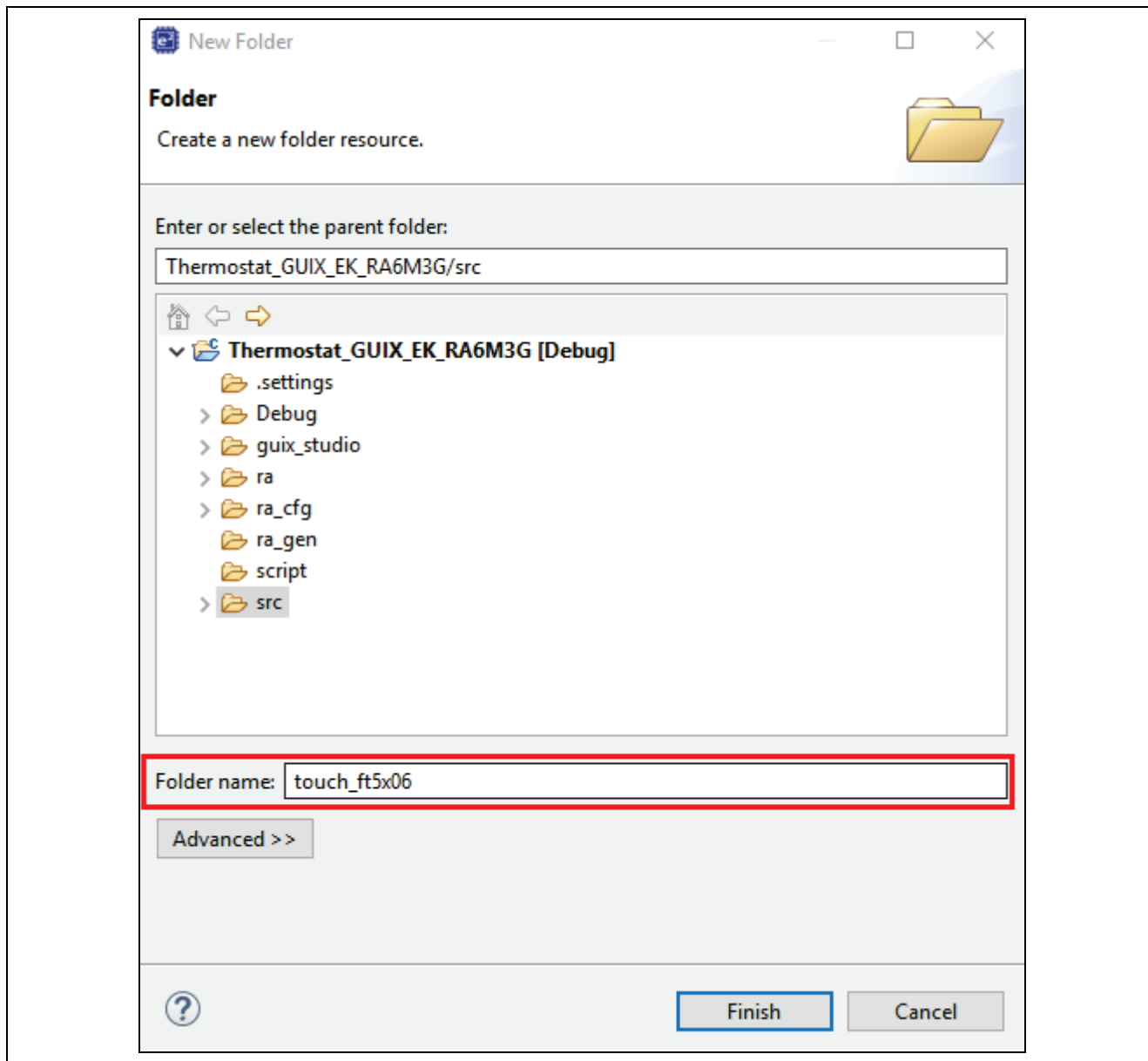


Figure 33. Creating New Folder in Thermostat_GUIX_EK_RA6M3G Project

Click **Finish** to create “touch_ft5x06” folder.

2. Copy `touch_ft5x06.c` and `touch_ft5x06.h` from “touch_ft5x06” folder in the Lab folder to the one in e² studio project.

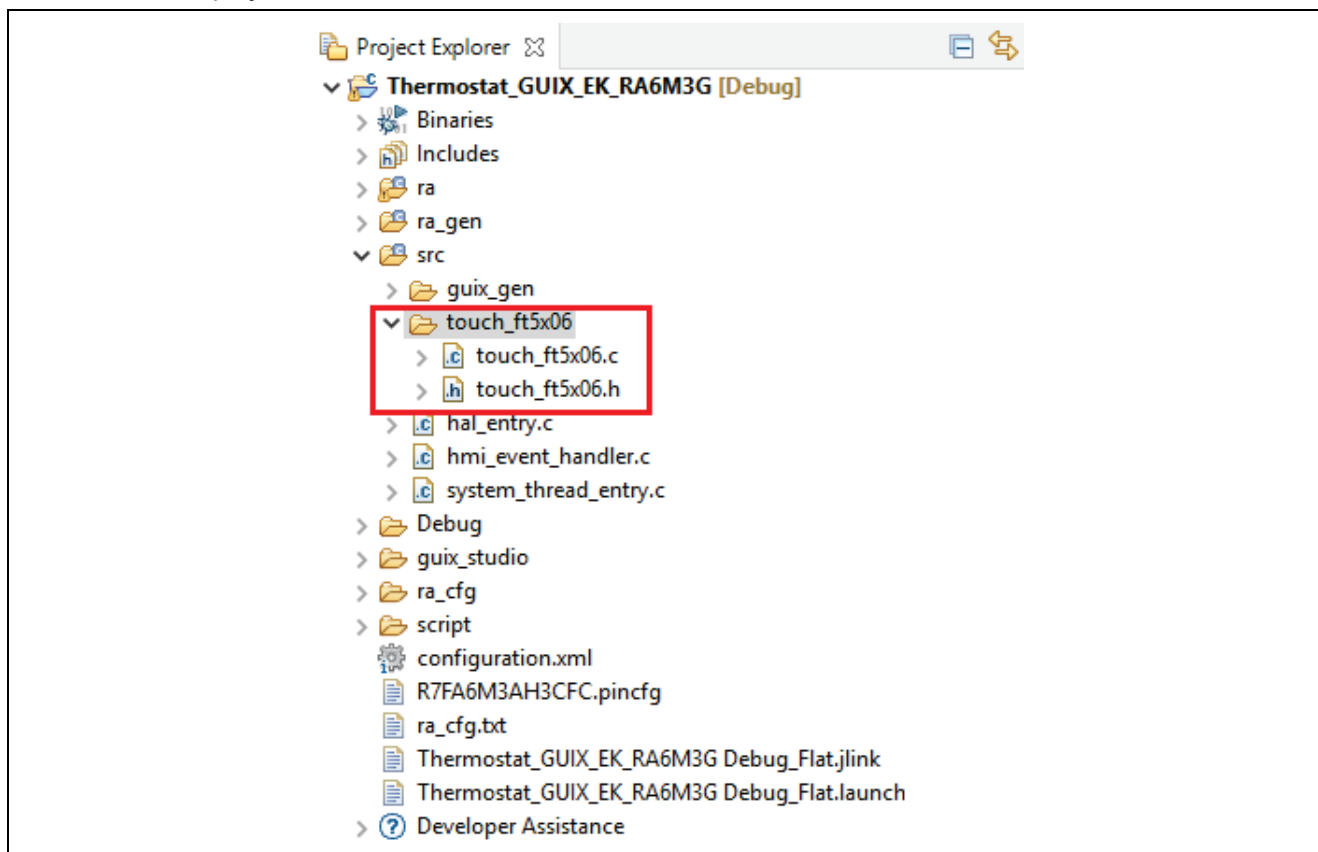


Figure 34. Copying files to the e² studio Project

3. Open project configuration and create **Touch Thread** with below settings.

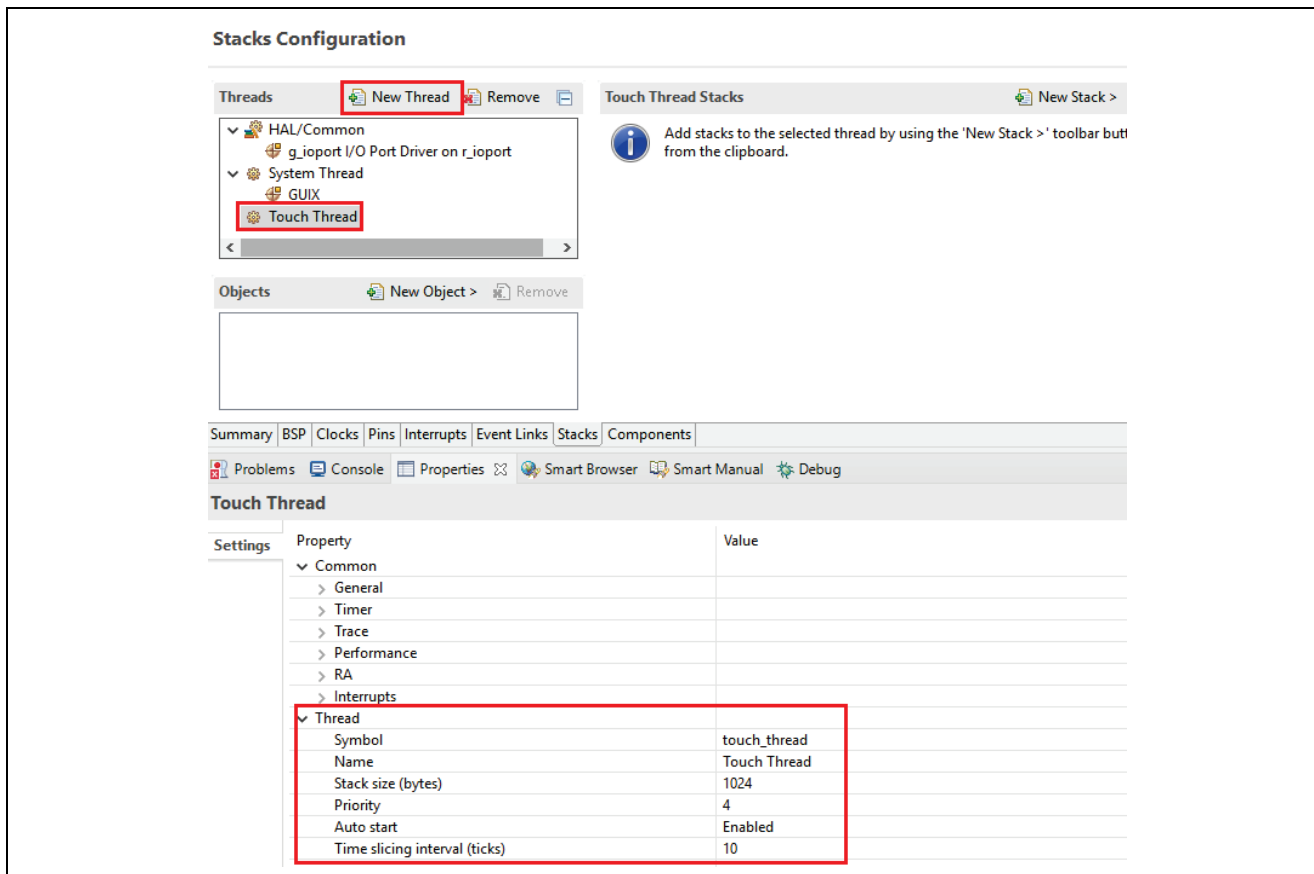


Figure 35. Creating Touch Thread

4. The pins marked in red below are used for touch panel controller on the LCD board:

- IRQ0 interrupt (P206) is used to trigger touch events.
- I2C channel 2 (P512, P511) is used to read and write data to the touch controller. P304 is used to reset the touch controller.

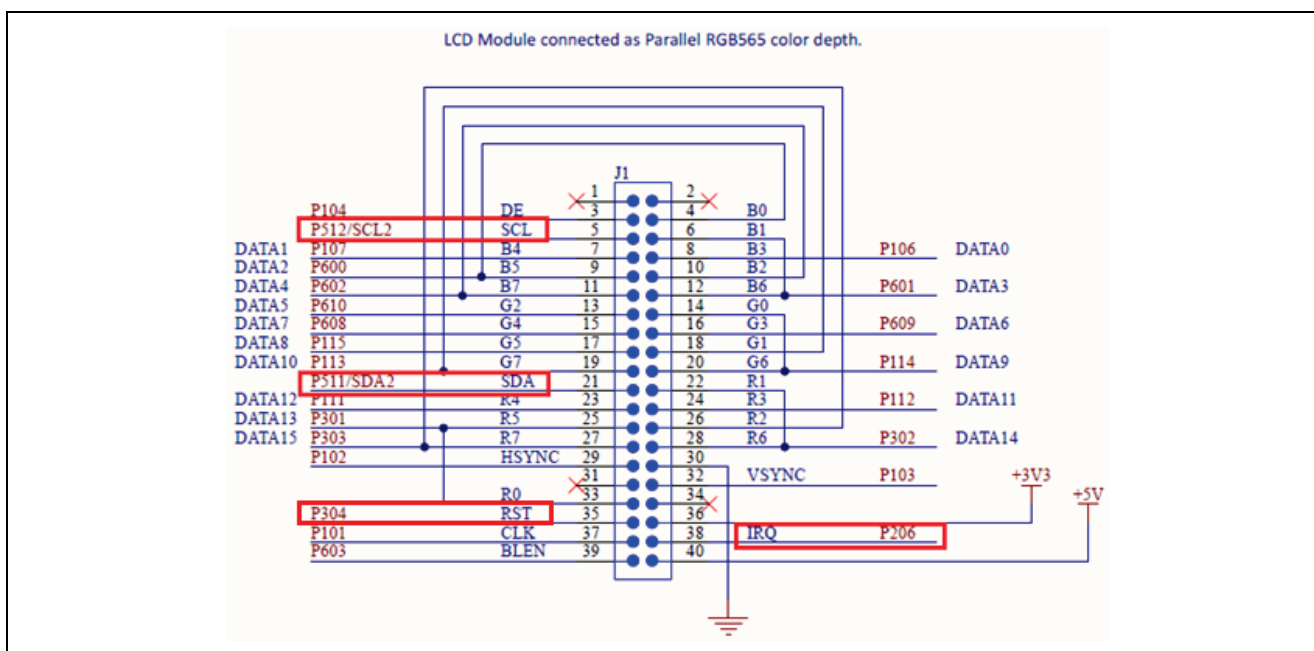


Figure 36. Pins Used in Touch Panel Controller (marked in red)

5. Since the IRQ0 (P206) needs a pull-up to function properly with the LCD board, do not change the setting that was done by FSP, as shown below.

Pin Configuration

Select Pin Configuration [Export to CSV file](#) [Configure Pin Driver Warnings](#)

RA6M3G-EK.pincfg [Manage configurations...](#) ☒ Generate data: g_bsp_pin_cfg

Pin Selection

Type filter text

- ✓ P2
 - P200
 - P201
 - ✓ P202
 - ✓ P203
 - ✓ P204
 - ✓ P205
 - ✓ P206
 - P207
 - ✓ P208
 - ✓ P209
 - ✓ P210
 - ✓ P211
 - ✓ P212
 - ✓ P213

Pin Configuration

Name	Value	Link
Symbolic Name		
Comment		
Mode	Input mode	
Pull up	input pull-up	
IRQ	IRQ0-DS	
Drive Capacity	Low	
Output type	CMOS	
Input/Output		
P206	✓ GPIO	

Module name: P206
Port Capabilities: BUS0: WAIT
CTS00: TS01

Pin Function Pin Number

Summary BSP Clocks Pins Interrupts Event Links Stacks Components

Figure 37. FSP Setting

6. In e² studio project configuration, add **External IRQ Driver on r_icu** to **Touch Thread** with the following settings.

Stacks Configuration

Threads [New Thread] [Remove] [Icon]

- HAL/Common
 - g_ioport I/O Port Driver on r_ioport
- System Thread
 - GUIX
 - Touch Thread**
 - g_touch_irq External IRQ Driver on r_icu

Objects [New Object >] [Remove]

Touch Thread Stacks

- g_touch_irq External IRQ Driver on r_icu

Summary | BSP | Clocks | Pins | Interrupts | Event Links | **Stacks** | Components

Problems | Console | Properties | Smart Browser | Smart Manual | Debug

g_external_irq0 External IRQ Driver on r_icu

Settings	Property	Value
API Info	Common	
	Parameter Checking	Default (BSP)
	Module g_external_irq0 External IRQ Driver on r_icu	
	Name	g_touch_irq
	Channel	0
	Trigger	Falling
	Digital Filtering	Enabled
	Digital Filtering Sample Clock (Only valid when Digital Filter	PCLK / 64
	Callback	touch_irq_cb
	Pin Interrupt Priority	Priority 5
Pins		
	IRQ00	None

Figure 38. Adding External IRQ Driver on r_icu to Touch Thread

7. In project configuration, add **I2C Master Driver on r_iic_master** to **Touch Thread** with below settings.

Stacks Configuration

Threads

- HAL/Common
 - g_ioport I/O Port Driver on r_ioport
 - System Thread
 - GUIX
 - Touch Thread**
 - g_touch_irq External IRQ Driver on r_licu

Objects

Touch Thread Stacks

- g_touch_irq External IRQ Driver on r_licu
- g_i2c_touch I2C Master Driver on r_iic_master**
- g_transfer0 Transfer Driver on r_dtc IIC2 TXI (Transmit data empty)
- g_transfer1 Transfer Driver on r_dtc IIC2 RXI (Receive data full)

g_i2c_touch I2C Master Driver on r_iic_master

Property	Value
Common	
Parameter Checking	Default (BSP)
DTC on Transmission and Reception	Disabled
10-bit slave addressing	Disabled
Module g_i2c_touch I2C Master Driver on r_iic_master	
Name	g_i2c_touch
Channel	2
Rate	Fast-mode
Rise Time (ns)	120
Fall Time (ns)	120
Duty Cycle (%)	50
Slave Address	0x38
Address Mode	7-Bit
Timeout Mode	Short Mode
Callback	touch_i2c_callback
Interrupt Priority Level	Priority 6
Pins	
SDA	P511
SCL	P512

Figure 39. Adding I2C Master Driver on r_iic_master to Touch Thread

8. In project configuration, add **Touch Semaphore** as shown below. We use this semaphore to signal the Touch thread when a touch event occurred. The Touch thread then sends the touch event to GUIX.

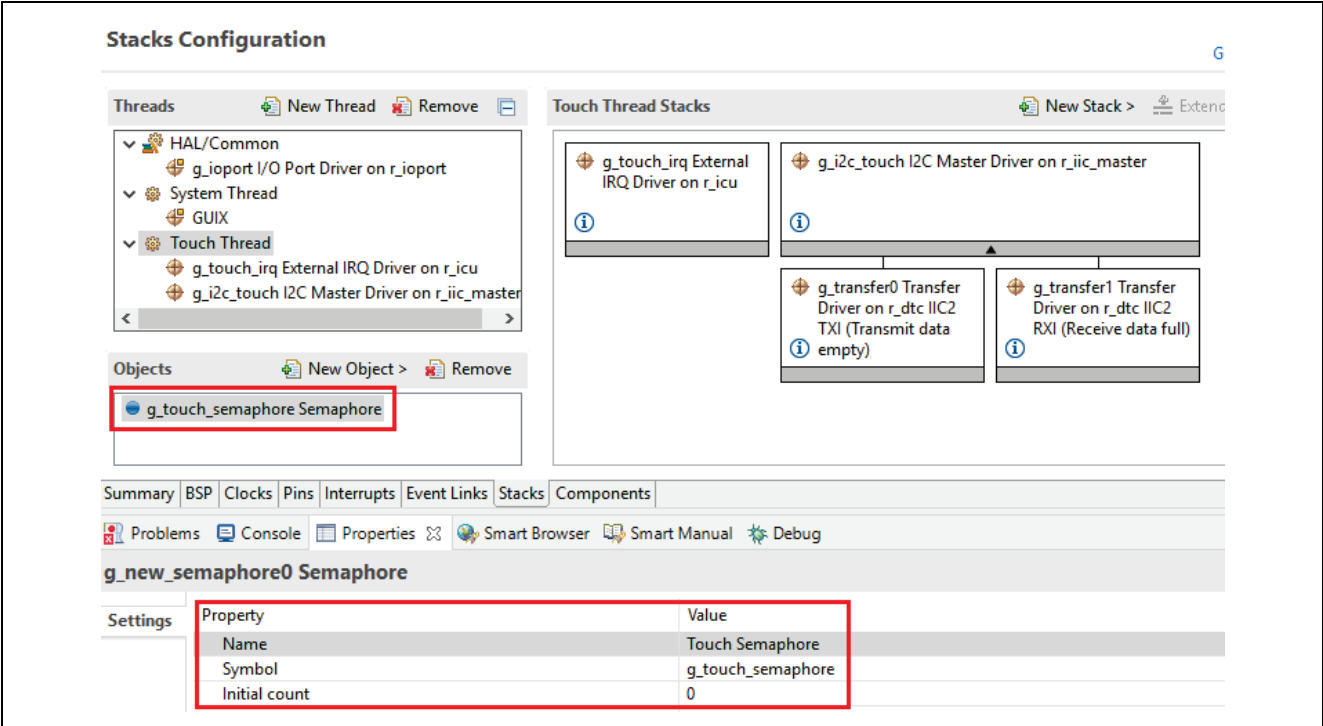


Figure 40. Adding Touch Semaphore

9. In project configuration, add **I2C Semaphore** as shown below. This semaphore is used in the ft5x06 driver to trigger data reading when a touch-panel interrupt occurred.

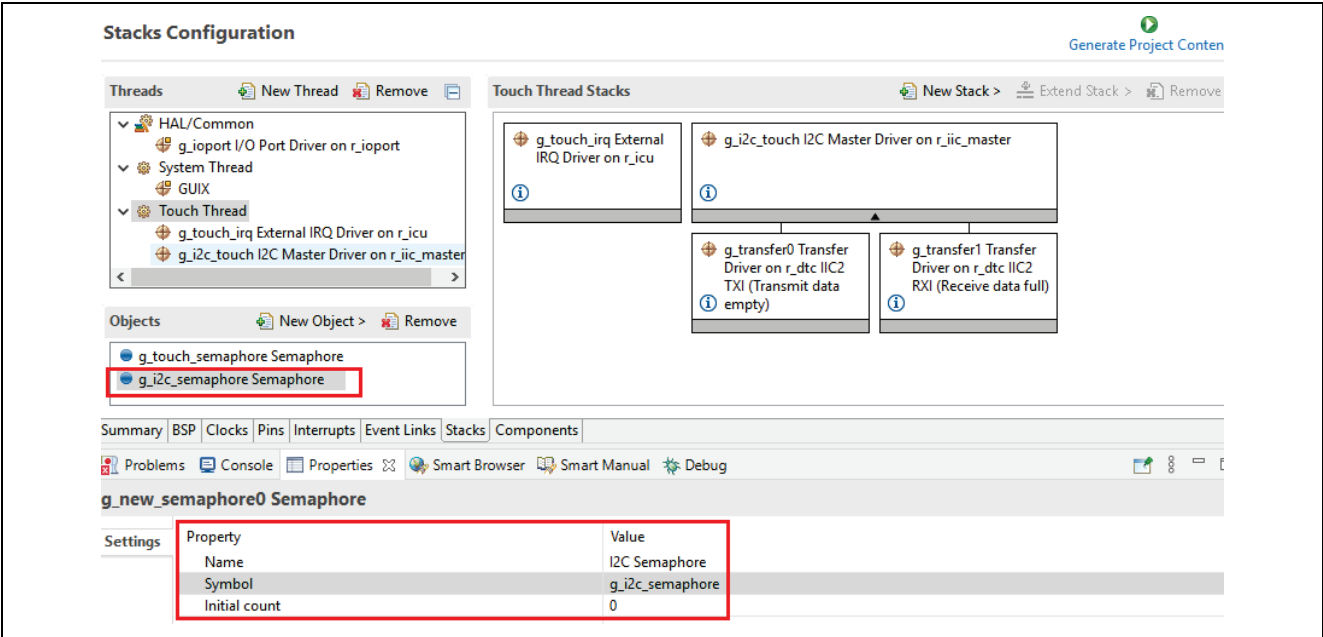


Figure 41. Adding I2C Semaphore



10. In RA Configurator, click **Generate Project Content** to generate project content.
11. Copy and replace the files in “src” folder in the e² studio project with the files in “4.11” folder in the AN folder:

- hmi_event_handler.c
- system_thread_entry.c
- touch_thread_entry.c

12. **Code highlight:** Below code in touch_thread_entry.c get touch data and send touch event to GUIX.

```
/* Get touch data from the FT5X06 */
ft5x06_payload_get(&touch_data);
/* Send touch data*/
if(1 == touch_data.num_points)
{
    gxe.gx_event_payload.gx_event_pointdata.gx_point_x    = touch_data.point[0].x;
    gxe.gx_event_payload.gx_event_pointdata.gx_point_y    = touch_data.point[0].y;
    gxe.gx_event_type = GX_EVENT_PEN_DOWN;
    gx_system_event_send(&gxe);
}
else if (GX_EVENT_PEN_DOWN == gxe.gx_event_type)
{
    gxe.gx_event_type = GX_EVENT_PEN_UP;
    gx_system_event_send(&gxe);
}
```

13. All the screens designed in the Azure RTOS GUIX Studio project are now created in system_thread_entry.c

```
/* Create a screen and attached it to root window.*/
gx_err = gx_studio_named_widget_create("Splash", (GX_WIDGET *) p_root, (GX_WIDGET **) &p_splash_screen);
if(GX_SUCCESS != gx_err)
{
    APP_ERR_TRAP(FSP_ERR_ASSERTION);
}

gx_err = gx_studio_named_widget_create ("Settings", GX_NULL, (GX_WIDGET **) &p_settings_screen);
if(GX_SUCCESS != gx_err)
{
    APP_ERR_TRAP(FSP_ERR_ASSERTION);
}

gx_err = gx_studio_named_widget_create ("MainPage", GX_NULL, (GX_WIDGET **) &p_mainpage_screen);
if(GX_SUCCESS != gx_err)
{
    APP_ERR_TRAP(FSP_ERR_ASSERTION);
}

gx_err = gx_studio_named_widget_create ("Thermostat", GX_NULL, (GX_WIDGET **) &p_thermostat_screen);
if(GX_SUCCESS != gx_err)
{
    APP_ERR_TRAP(FSP_ERR_ASSERTION);
}

gx_err = gx_studio_named_widget_create ("Help", GX_NULL, (GX_WIDGET **) &p_help_screen);
if(GX_SUCCESS != gx_err)
{
    APP_ERR_TRAP(FSP_ERR_ASSERTION);
}
```

The code marked in red in hmi_event_handler.c handle touch event when Thermostat button and Settings button are clicked. Refer to hmi_event_handler.c for more details.

```

>UINT mainpage_event(GX_WINDOW *widget, GX_EVENT *event_ptr)
{
    UINT gx_err = GX_SUCCESS;
    switch (event_ptr->gx_event_type)
    {
        case GX_SIGNAL(ID_THERMO_BUTTON, GX_EVENT_CLICKED):
            /** Shows the thermostat control screen. */
            toggle_screen (p_thermostat_screen, p_mainpage_screen);
            break;
        case GX_SIGNAL(ID_SETTINGS_BUTTON, GX_EVENT_CLICKED):
            /** Shows the settings screen and saves which screen the user is currently viewing. */
            toggle_screen (p_settings_screen, widget);
            break;
        case GX_EVENT_SHOW:
            gx_err = gx_window_event_process(widget, event_ptr);
            if(GX_SUCCESS != gx_err) {
                while(1);
            }
            break;
        default:
            gx_err = gx_window_event_process(widget, event_ptr);
            if(GX_SUCCESS != gx_err) {
                while(1);
            }
            break;
    }
    return gx_err;
}

UINT settings_screen_event(GX_WINDOW *widget, GX_EVENT *event_ptr)
{
    UINT gx_err = GX_SUCCESS;
    switch (event_ptr->gx_event_type)
    {
        case GX_SIGNAL(ID_BACK_BUTTON, GX_EVENT_CLICKED):
            /** Returns to main screen. */
            toggle_screen (p_mainpage_screen, widget);
            break;
        case GX_EVENT_SHOW:
            gx_err = gx_window_event_process(widget, event_ptr);
            if(GX_SUCCESS != gx_err) {
                while(1);
            }
            break;
        default:
            gx_err = gx_window_event_process(widget, event_ptr);
            if(GX_SUCCESS != gx_err) {
                while(1);
            }
            break;
    }
    return gx_err;
}

```

14. **Build, Download, and Run** the e² studio project. Then, you will be able to go back and forth from Main Page screen to Thermostat screen and Settings screen using **Thermostat** and **Settings** buttons on Main Page screen and “**Back**” button on the other two screens.

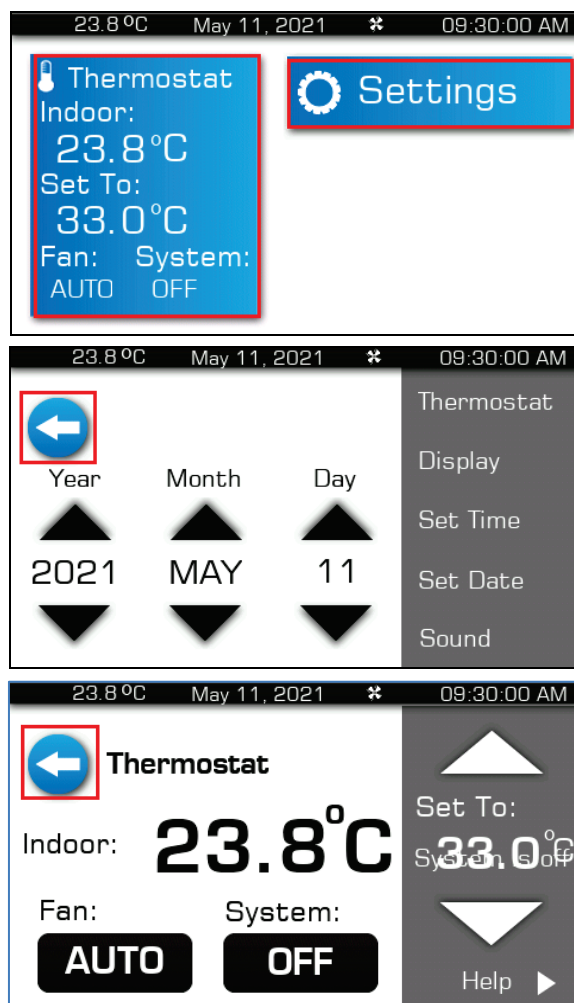


Figure 42. Navigating between Main Page Screen and Thermostat Screen

5. Control LCD Backlight

5.1 Overview

In this section, you will use a PWM output pin of a GPT timer to control the intensity (brightness) of LCD backlight.

5.2 Procedural Steps

- 1. In LCD board schematics below, the LCD_BLEN signal, which is connected to the P603 on the RA6M3 MCU, is configuring in PWM mode to control the intensity of LCD backlight.

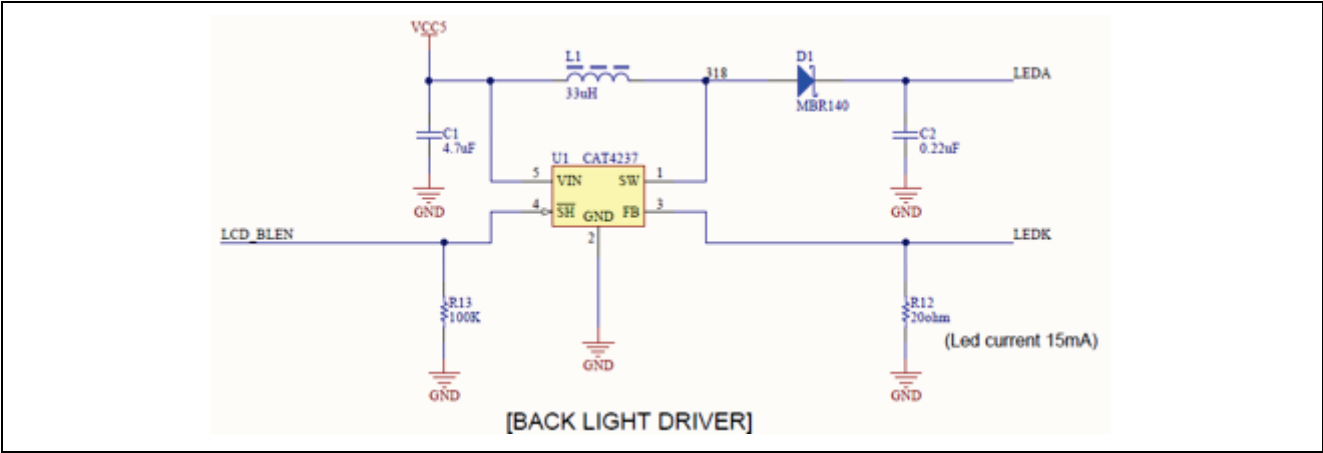


Figure 43. LCD Board Schematic

- 2. To configure P603 in PWM output mode, we disable it in Pin Configuration at first. **Save this change before moving to the next step.**

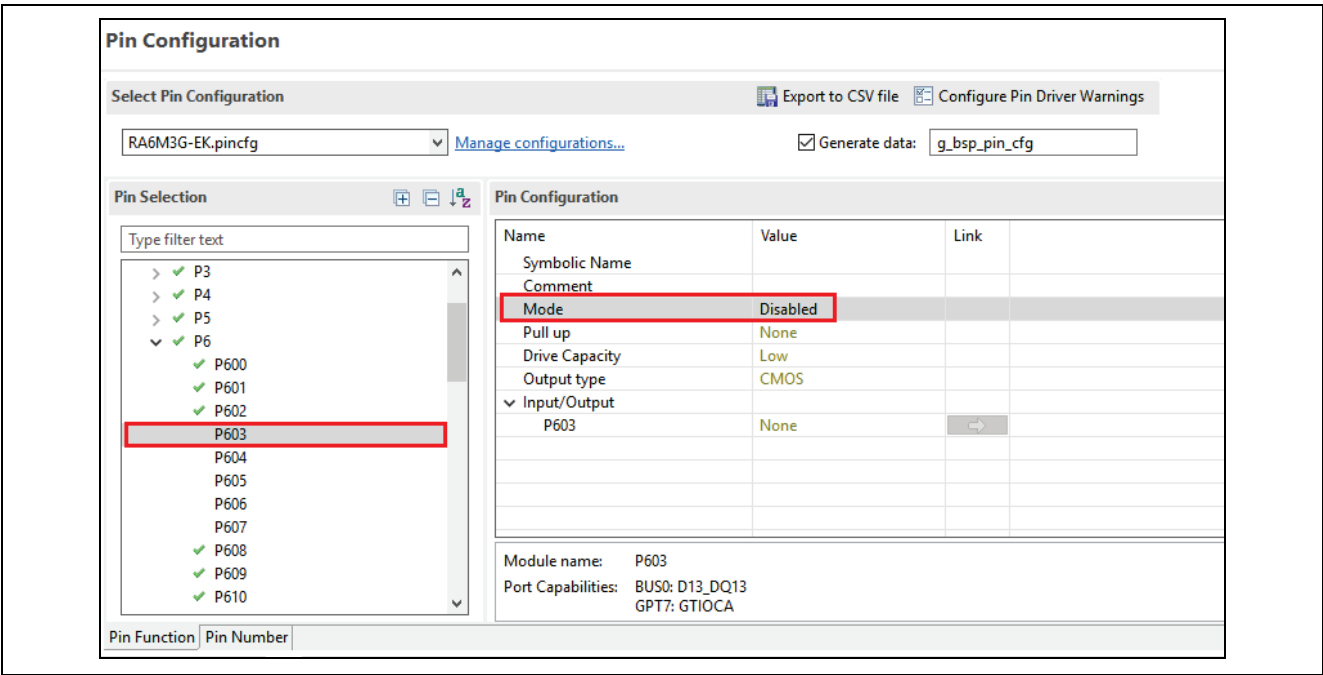


Figure 44. Disabling P603 in Pin Configuration

3. In Pin Configuration, set P603 as GPT7 GTIOCA output.

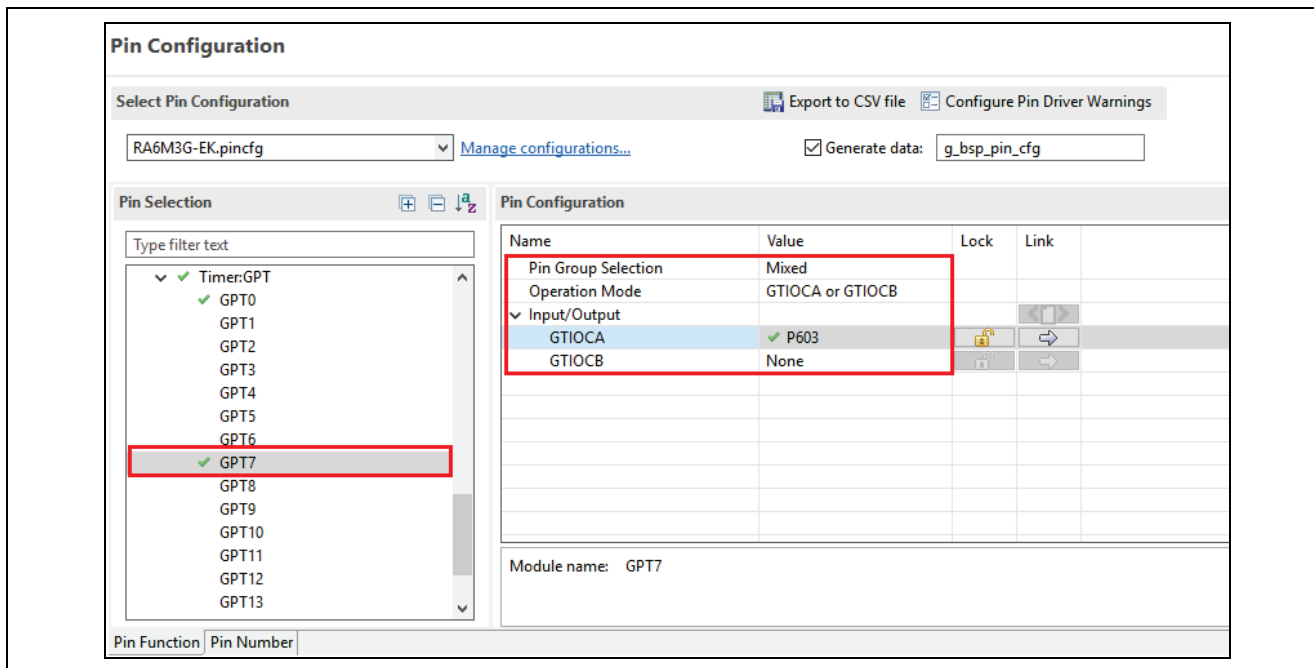


Figure 45. Setting P603 as GPT7 GTIOCA Output in Pin Configuration

4. In project configuration, add **Timer Driver on r_gpt** to **System Thread** with below settings.

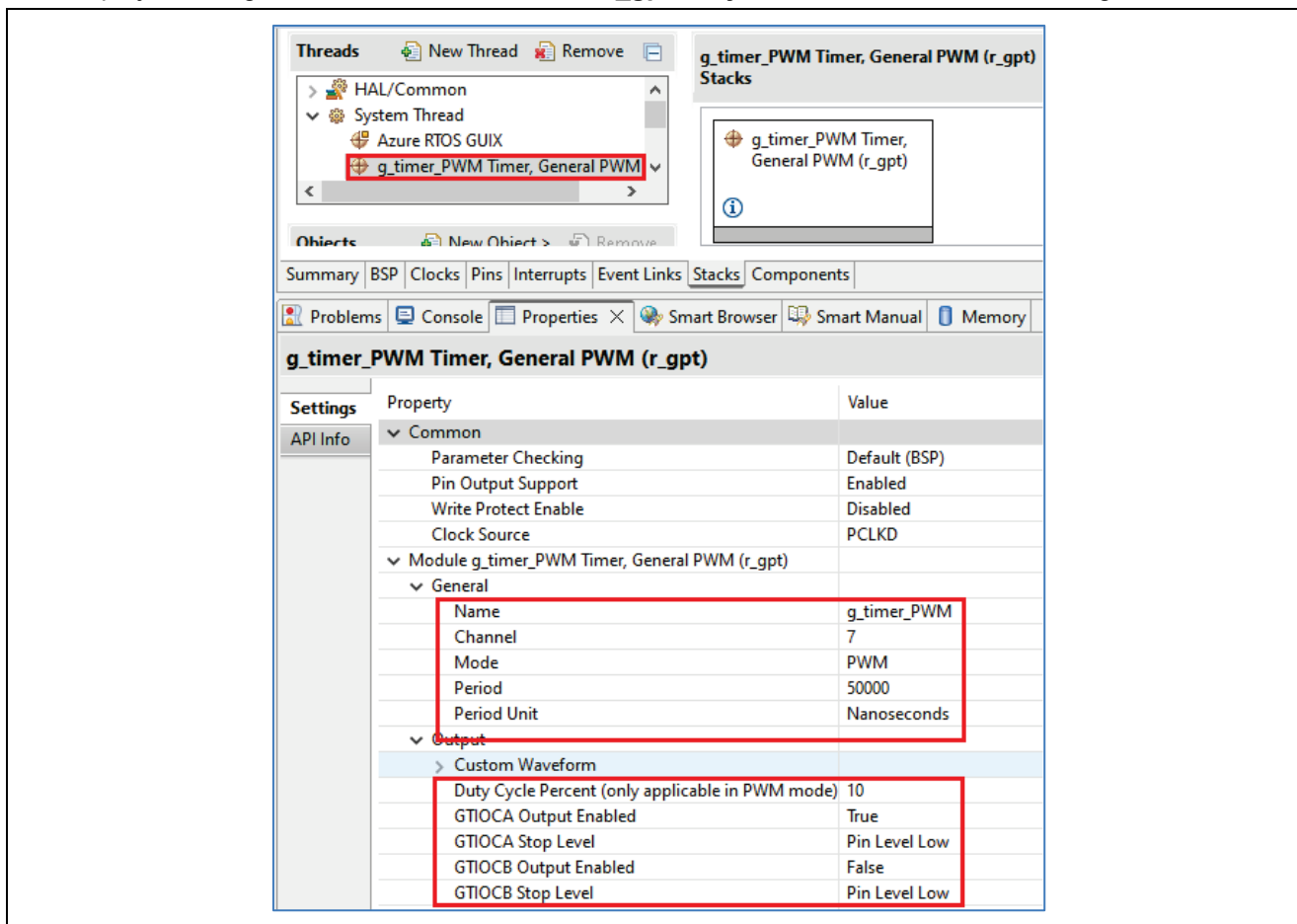


Figure 46. Adding Timer Driver on r_gpt to System Thread

Even though the duty cycle of PWM output is purposely set to **10%** here, it will be changed to **50%** later in the code.



5. In RA Configurator, click **Generate Project Content** to generate project content.
6. Copy and replace the files in "src" folder in e2 studio project with the files in "5.6" folder in the AN folder:
 - hmi_event_handler.c
 - system_thread_entry.c
 - brightness.c
 - brightness.h
 - system_api.h
 - system_cfg.h
7. brightness_up and brightness_down functions in brightness.c are used to set the PWM duty cycle, as shown below:


```
/* Get the current period setting. */
R_GPT_InfoGet(&g_timer_PWM_ctrl, &info);
/* Calculate the desired duty cycle based on the current period. */
duty_cycle_count = (uint32_t) ((info.period_counts *
brightness)/GPT_PWM_MAX_PERCENT);
err = R_GPT_DutyCycleSet(&g_timer_PWM_ctrl, duty_cycle_count,
GPT_IO_PIN_GTIOCA);
```
8. Looking at gpt_timer_PWM_Setup function in system_thread_entry.c, you will see brightness (**duty cycle of PWM output**) is set to 50 percent.

```
static fsp_err_t gpt_timer_PWM_setup(void)
{
    fsp_err_t err = FSP_SUCCESS;
    /* Open GPT */
    err = R_GPT_Open(&g_timer_PWM_ctrl, &g_timer_PWM_cfg);
    if(FSP_SUCCESS != err)
    {
        return err;
    }
    /* Enable GPT Timer */
    err = R_GPT_Enable(&g_timer_PWM_ctrl);
    /* Handle error */
    if (FSP_SUCCESS != err)
    {
        return err;
    }
    /* Start GPT timer */
    err = R_GPT_Start(&g_timer_PWM_ctrl);
    if(FSP_SUCCESS != err)
    {
        return err;
    }

    /* Set brightness (LCD backlight) level: 50 = (45+5) */
    g_gui_state.brightness = 45;
    brightness_up(&g_gui_state.brightness);

    return err;
}
```

9. **Build, Download, and Run** the e² studio project. By clicking **Settings** button on **Main Page** screen, you can access **Settings** screen.

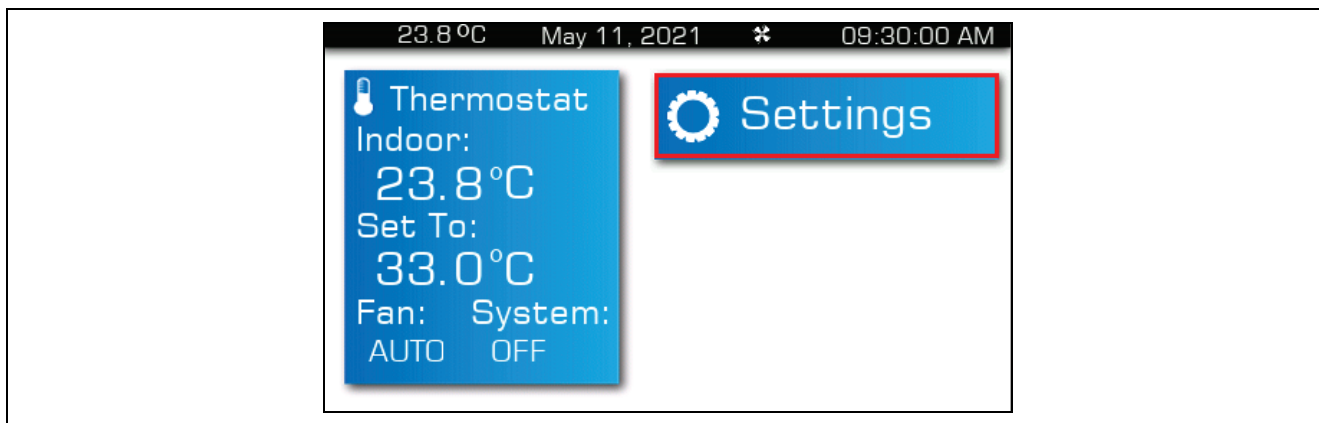


Figure 47. Settings Button on Main Page Screen

10. PWM output measured on pin P603 with brightness is set to 50%.

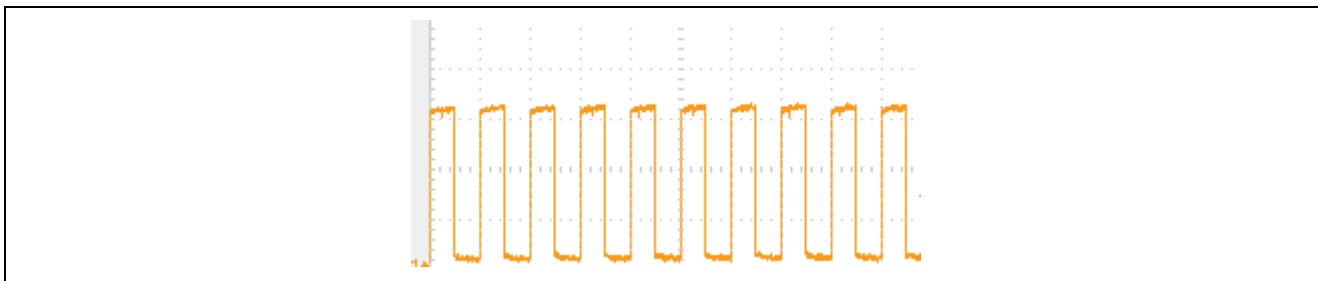


Figure 48. PWM Output on P603 at 50% Brightness

11. Click “**Display**” menu on **Settings** screen, you can use “**Up**” and “**Down**” buttons to change the brightness of LCD backlight.

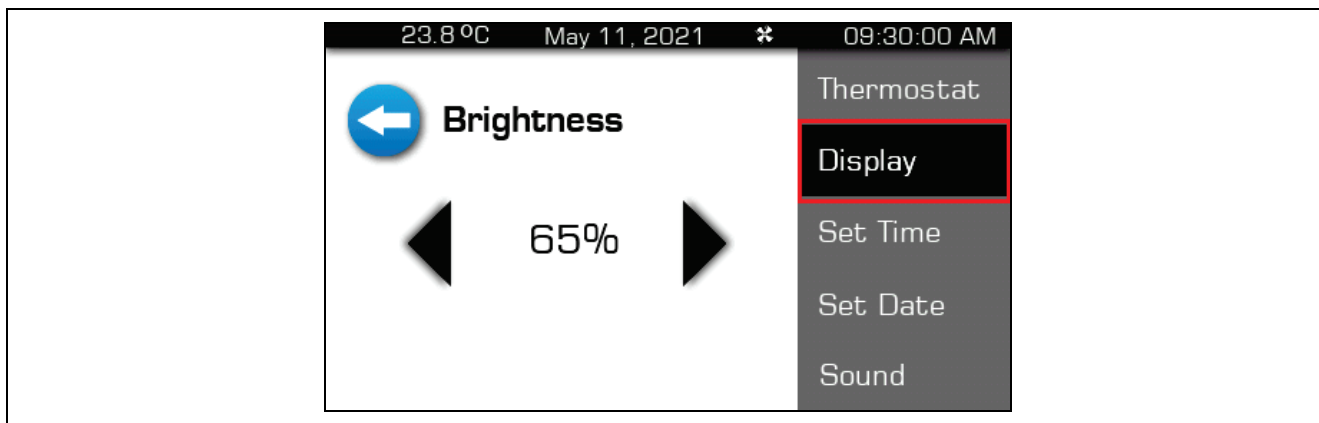


Figure 49. Display on Settings Screen

12. PWM output measured on pin P603 after changing brightness to **65%**.

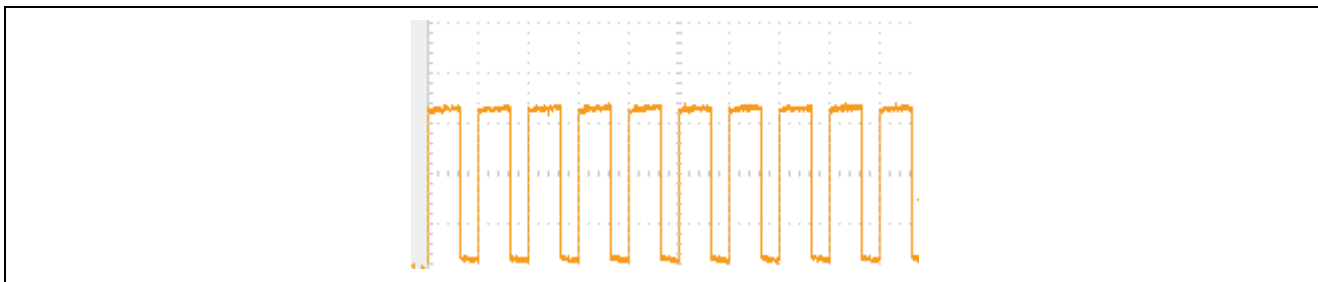


Figure 50. PWM Output on P603 at 65% Brightness

6. Update Date/Time and Temperature

6.1 Overview

In this section, you will enable RTC controller as a timekeeper and one ADC channel to read the MCU die's temperature sensor and use it as Thermostat temperature data.

6.2 Procedural Steps

1. In project configuration, add **RTC Driver on g_rtc** to **Temperature Time Thread**.

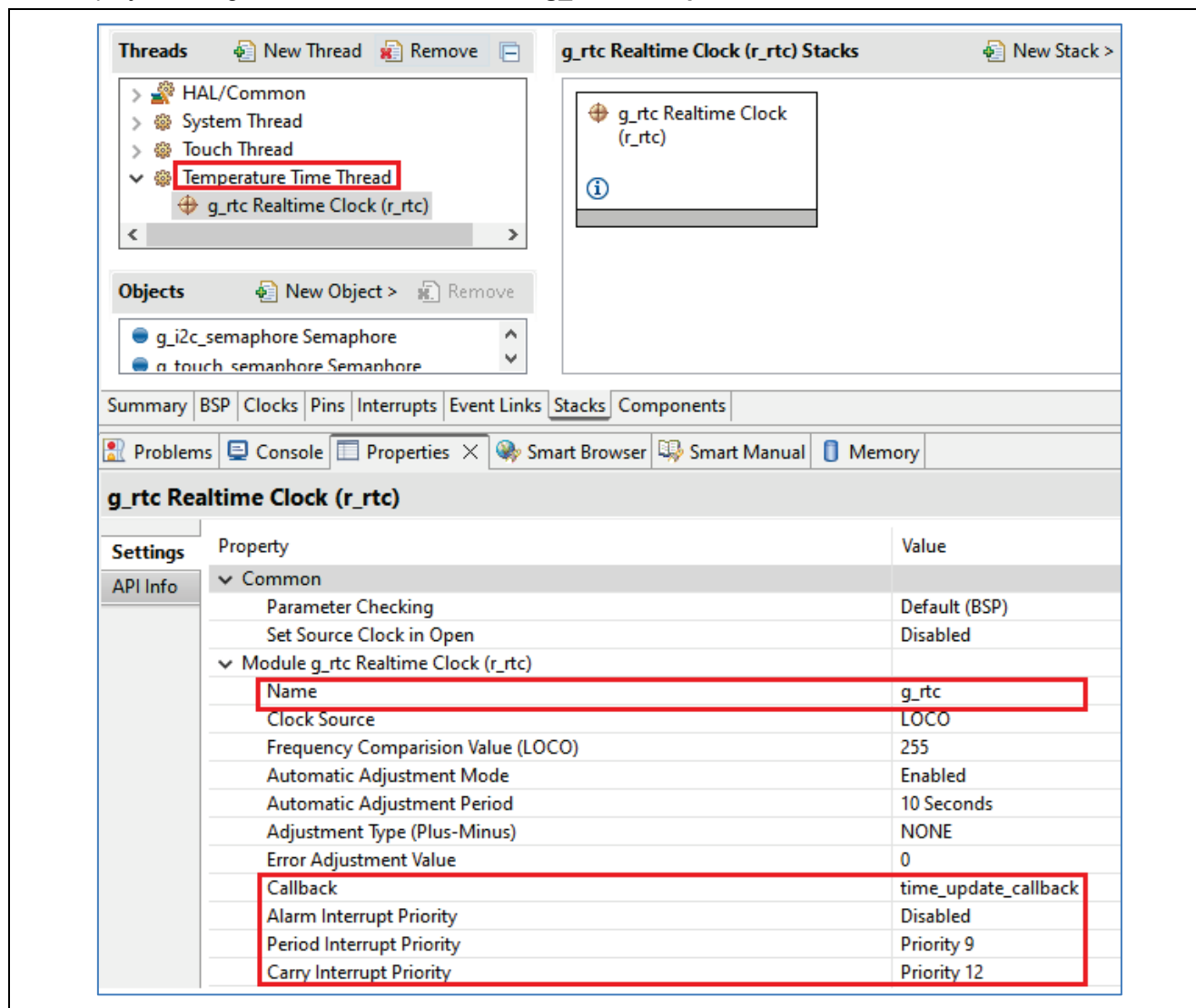


Figure 51. Adding RTC Driver on g_rtc to Temperature Time Thread

2. In project configuration, add **ADC Driver on r_adc** to **System Thread**.

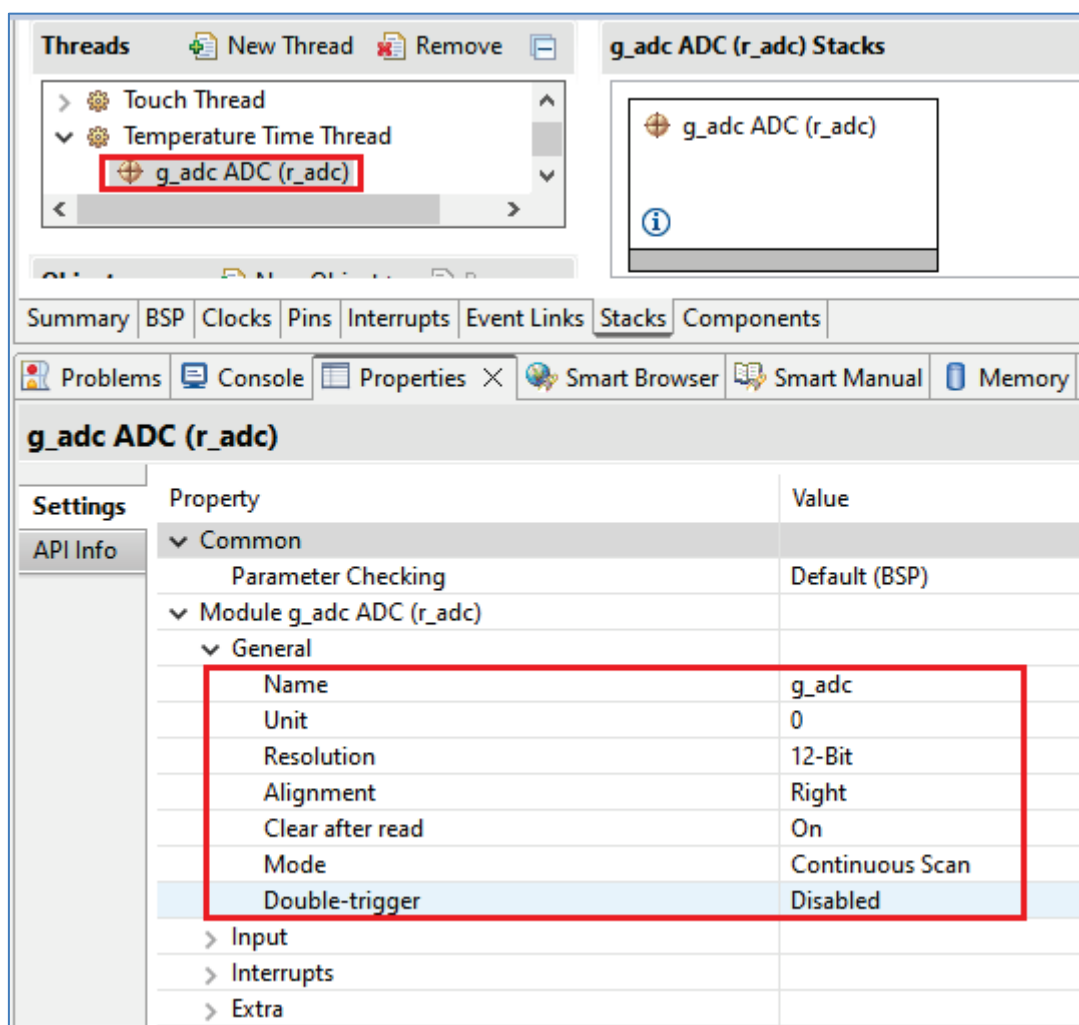


Figure 52. Adding ADC Driver on r_adc to System Thread

3. Select **Temperature Sensor** as input source for g_adc module.

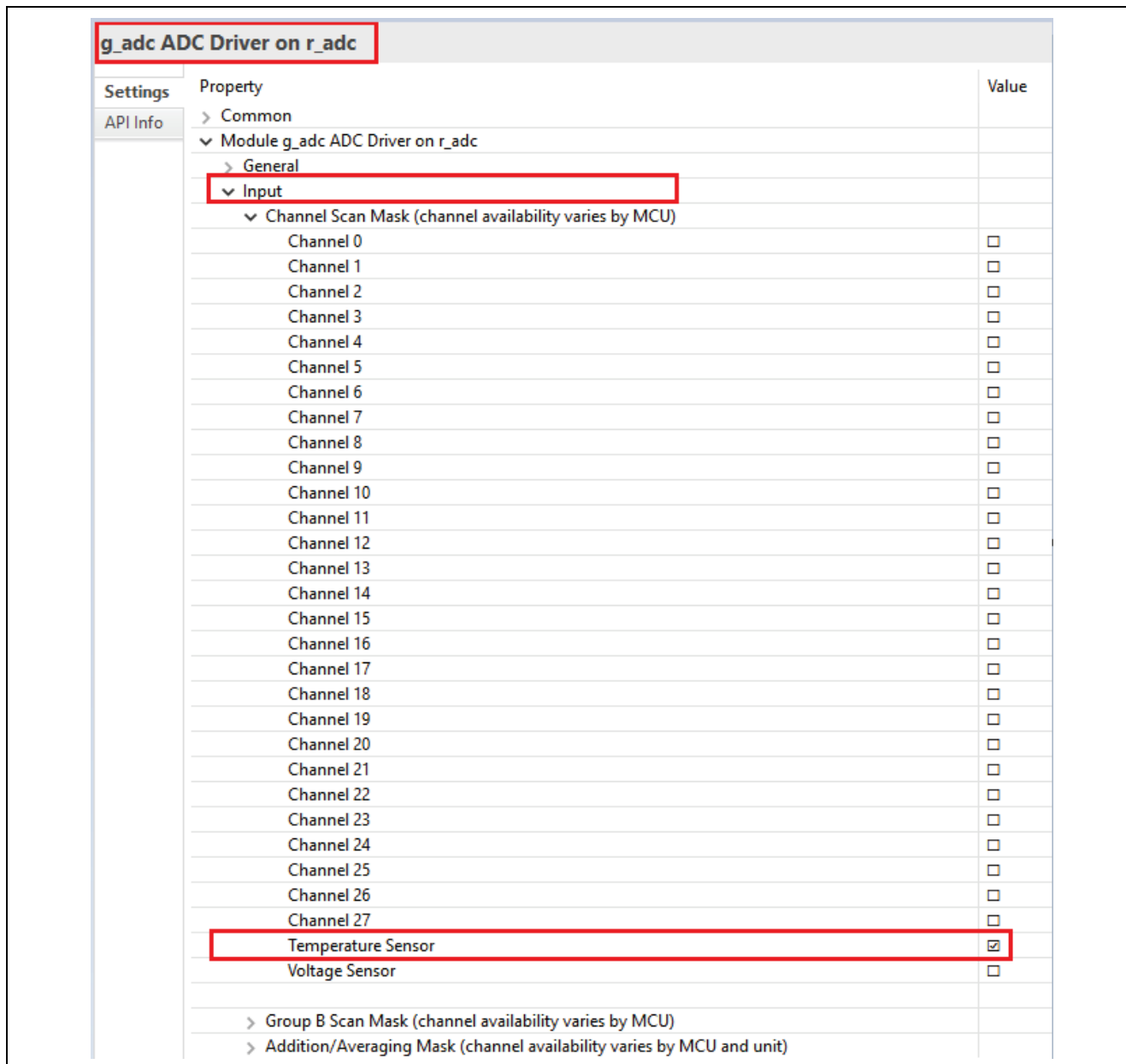


Figure 53. Selecting Temperature Sensor as Input Source for g_adc

4. Create **g_timer_semaphore** with the following settings. We use this semaphore to trigger the date and time update every second.

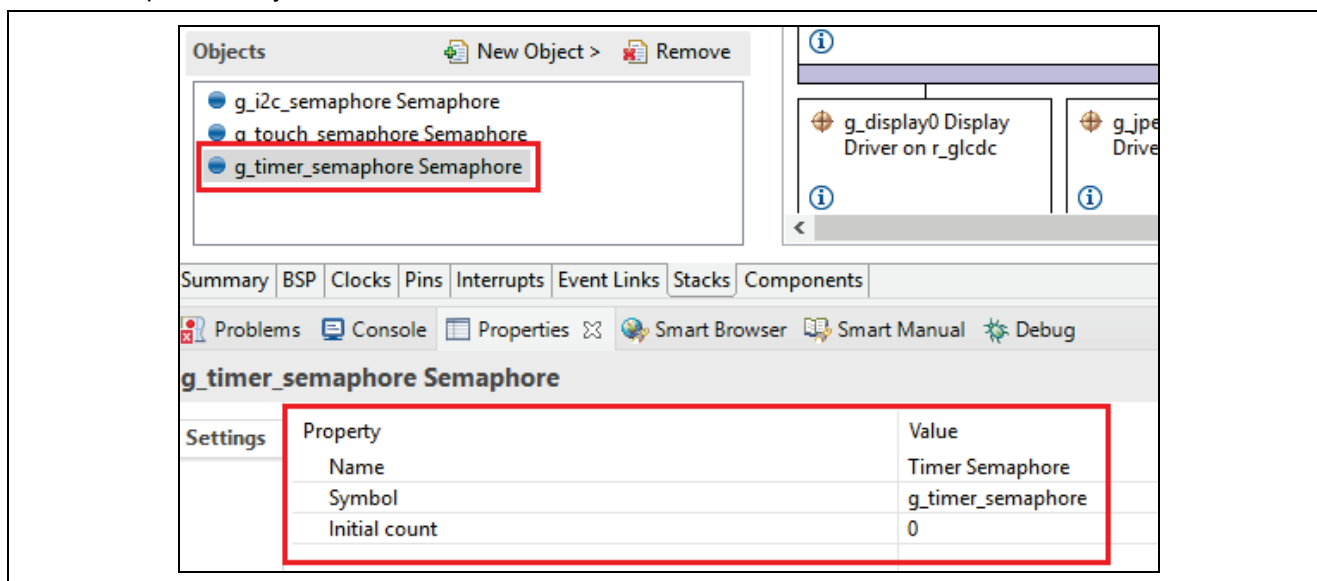



Figure 54. Creating g_timer_semaphore

5. In RA Configurator, click  **Generate Project Content** to generate project content.
6. Copy and replace the files in “src” folder in e² studio project with the files in “6.6” folder in the Lab folder:
 - hmi_event_handler.c
 - system_thread_entry.c
 - system_time.c
 - system_time.h
 - system_api.h

7. In System Thread, date/time data and temperature data get updated every second. It then sends out events to trigger GUIX updates.

```

while (1)
{
    /* Wait for RTC interrupt. */
    status = tx_semaphore_get(&g_timer_semaphore, TX_WAIT_FOREVER);
    if(TX_SUCCESS != status)
    {
        APP_ERR_TRAP(FSP_ERR_ASSERTION);
    }
    /* Get date, time */
    R_RTC_CalendarTimeGet(&g_rtc_ctrl, &g_gui_state.time);
    /* Send GUIX event to update time */
    send_hmi_message(GXEVENT_MSG_TIME_UPDATE);

    /* Delay and update temperature*/
    tx_thread_sleep (10);
    /* Read the temperature */
    err = R_ADC_Read(&g_adc_ctrl, ADC_CHANNEL_TEMPERATURE, &adc_temp_data);
    /* Handle error */
    if (FSP_SUCCESS != err)
    {
        APP_ERR_TRAP(err);
    }

    /* Conversion of ADC temperature in celsius */
    g_gui_state.temp_c = ADCTEMP_AS_C(adc_temp_data);

    /* Send GUIX event to update time */
    send_hmi_message(GXEVENT_MSG_UPDATE_TEMPERATURE);
    tx_thread_sleep (1);
}

```

8. Following is an example of handling temperature and time update events in the Main Page screen event handler.

```

UINT mainpage_event(GX_WINDOW *widget, GX_EVENT *event_ptr)
{
    UINT gx_err = GX_SUCCESS;
    switch (event_ptr->gx_event_type)
    {
        case GXEVENT_MSG_UPDATE_TEMPERATURE:
            /* Update temperature text. */
            update_local_temp_string();
            update_text((GX_WIDGET *) widget, ID_TEMP_TEXT, g_local_temp_str);
            update_text((GX_WIDGET *) widget, ID_TEMP_TEXT_2, g_local_temp_str);
            break;
        case GXEVENT_MSG_TIME_UPDATE:
            update_time ((GX_WIDGET *) widget, &g_gui_state);
            update_date((GX_WIDGET *) widget, &g_gui_state);
            break;
        case GX_SIGNAL(ID_THERMO_BUTTON, GX_EVENT_CLICKED):
            /* Shows the thermostat control screen. */
            toggle_screen (p_thermostat_screen, p_mainpage_screen);
            break;
        case GX_SIGNAL(ID_SETTINGS_BUTTON, GX_EVENT_CLICKED):
            /* Shows the settings screen and saves which screen the user is currently viewing. */
            toggle_screen (p_settings_screen, widget);
            break;
        case GX_EVENT_SHOW:
            gx_err = gx_window_event_process(widget, event_ptr);
            if(GX_SUCCESS != gx_err) {
                while(1);
            }
            break;
        default:
            gx_err = gx_window_event_process(widget, event_ptr);
            if(GX_SUCCESS != gx_err) {
                while(1);
            }
            break;
    }
    return gx_err;
}

```

9. **Build, Download, and Run** the e² studio project. You will see time and temperature get updated every second.

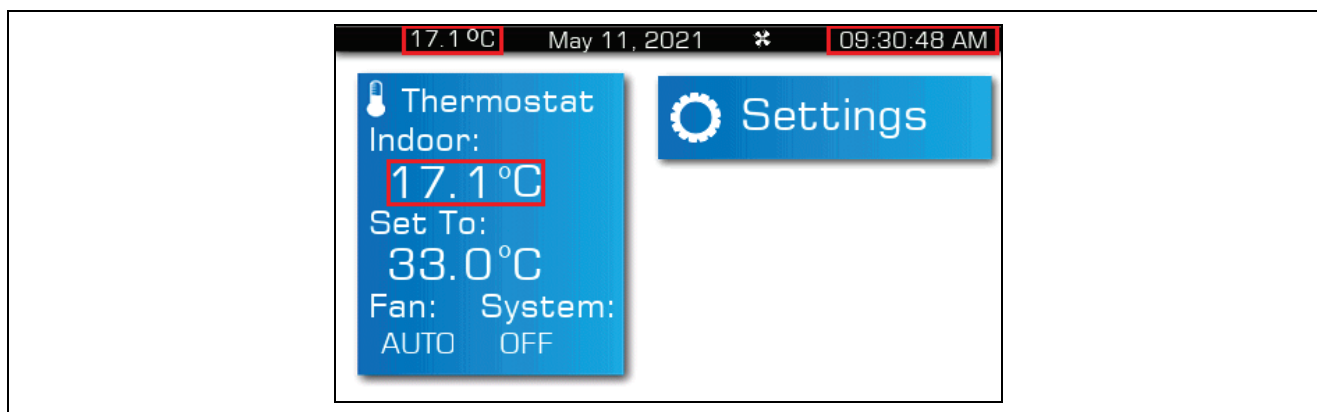


Figure 55. Time, Temperature on Main Page Screen

7. Setting Date/Time in A Full Function Project

7.1 Overview

In this section, you will import and run the complete Thermostat project that enable the settings of date and time. Upon user press date and time buttons on the settings screen, a message will be sent to the system thread to update the date and time, then the system thread will send a GUIX event to trigger time display update on screens.

7.2 Procedural Steps

1. You can try the completed project in “**completed_project**” folder that has a full function Thermostat application. Use “**Rename & Import Existing C/C++ Project into Workspace**” feature of **Import** menu in e² studio to do so since you already had a project with the same in the workspace.

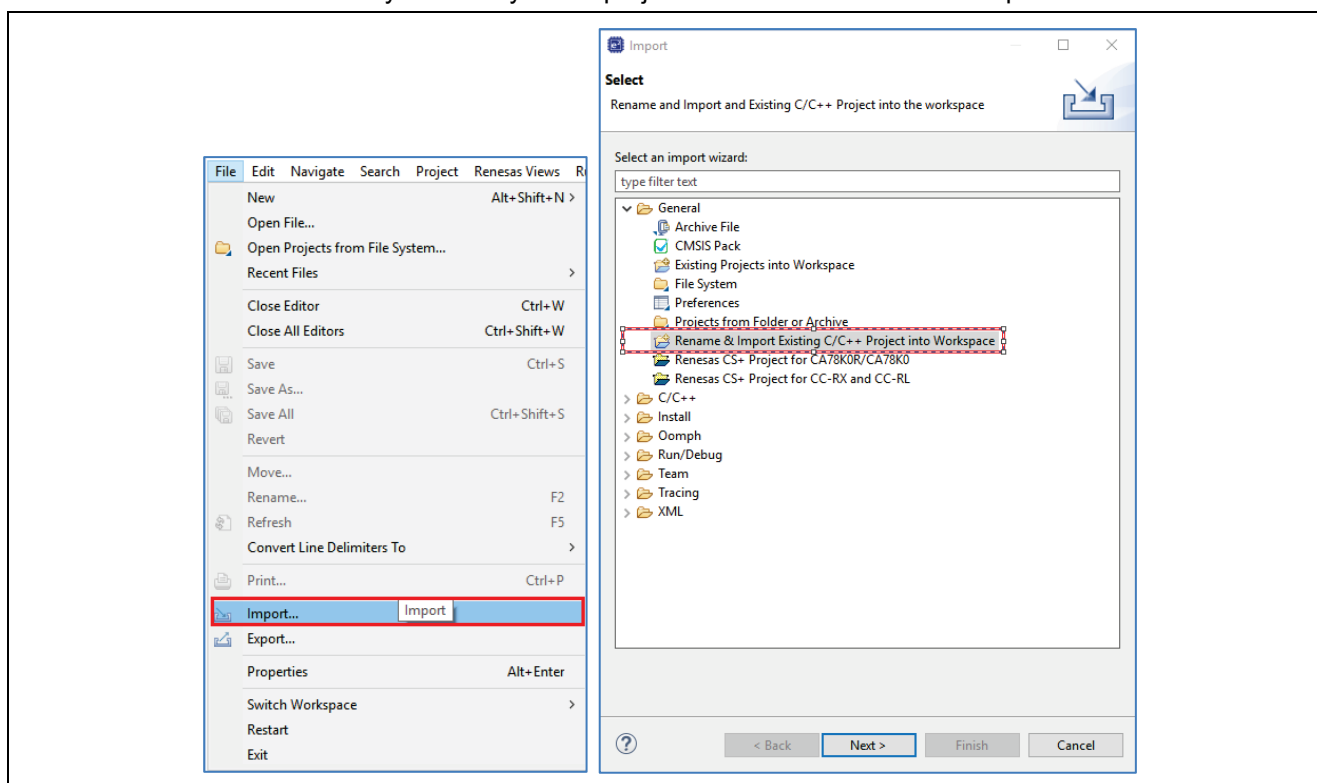


Figure 56. Rename & Import Existing C/C++ Project into Workspace on Import Menu

8. Website and Support

Visit the following URLs to learn about key elements of the RA family, download components and related documentation, and get support:

RA Product Information	renesas.com/ra
RA Product Support Forum	renesas.com/ra/forum
RA Flexible Software Package	renesas.com/FSP
Renesas Support	renesas.com/support

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Mar.31.23	—	Initial release
1.01	Jul.17.23	—	Updated for FSP v4.4.0.

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity.

Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

2. Processing at power-on

The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state

Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

4. Handling of unused pins

Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

5. Clock signals

After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

6. Voltage application waveform at input pin

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).

7. Prohibition of access to reserved addresses

Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products

Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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(Rev.5.0-1 October 2020)

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